

# **Large-eddy simulations of the response of tropopause moisture to deep convection**

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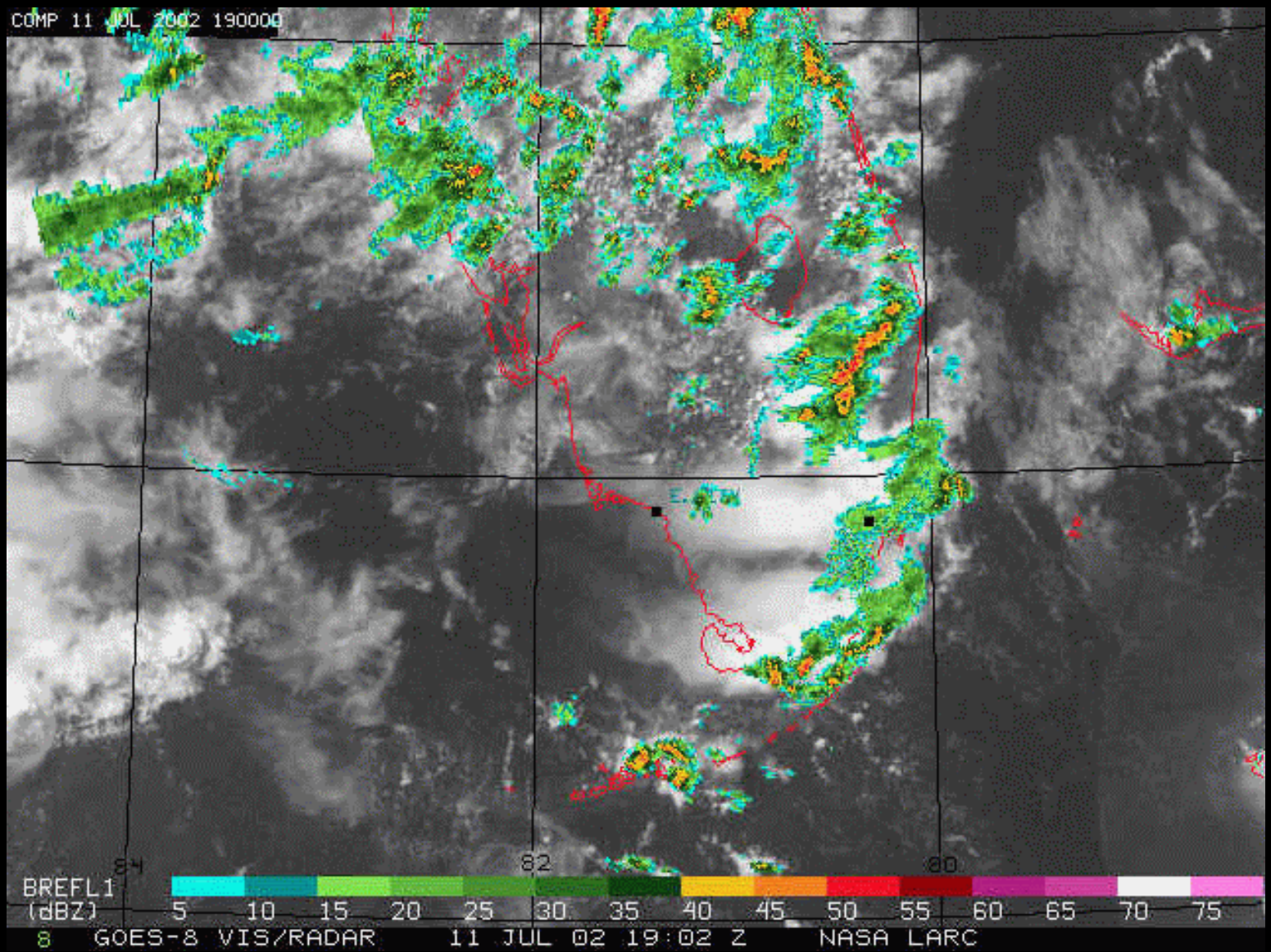
# Motivation

- Stratospheric moisture has increased over past decades (Oltmans and Hofmann, 1995)
- Stratospheric moisture plays important role in ozone depletion
- How does moisture enter the stratosphere?
  1. Gradual ascent through TTL
  2. Convective overshooting (Sherwood and Dessler, 2000, 2001)

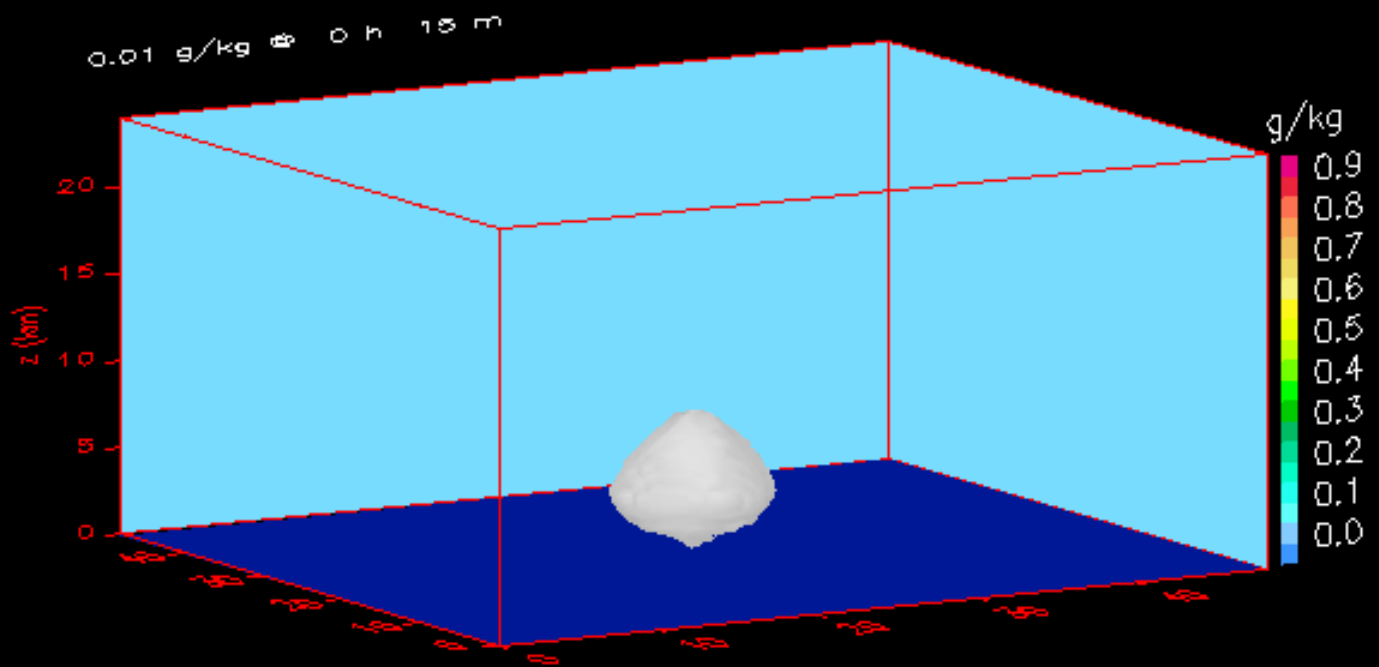
# Approach: LES of deep convection over Florida

- LES (Stevens and Bretherton, 1997):  $\Delta z=375$  m,  $\Delta x=\Delta y=500$  m
- Explicit, bin microphysics model of aerosols, water, and ice (Toon, Turco, Jensen, Ackerman, Fridlind)
- Simulate three "golden" anvil days: July 11, 16, and 29
- Model domain initialized to observed, pre-convective sounding (massaged by L. Miloshevich)
- Open lateral boundaries, nudge to initial sounding with zeroed horizontal winds
- Initiate convection with warm bubble that reaches tropopause
- Aerosol concentrations:  $500 \text{ cm}^{-3}$  to 4 km,  $150 \text{ cm}^{-3}$  above

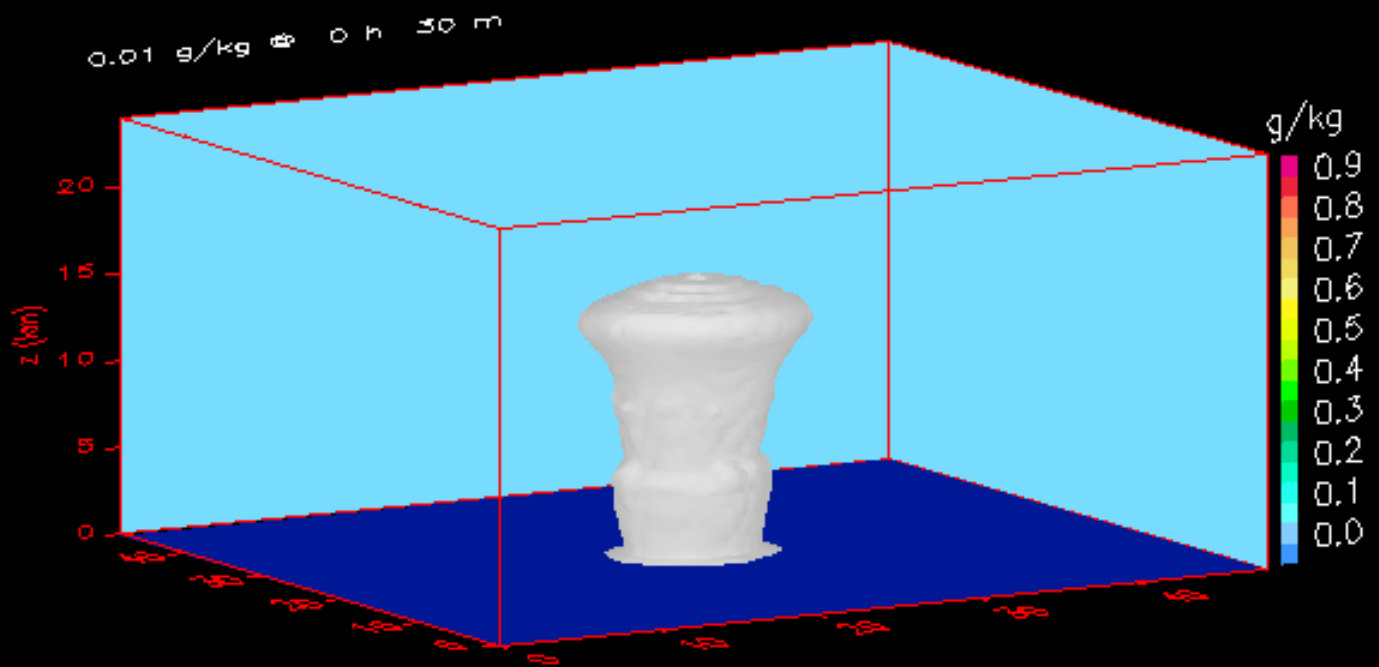
# Case study: July 11



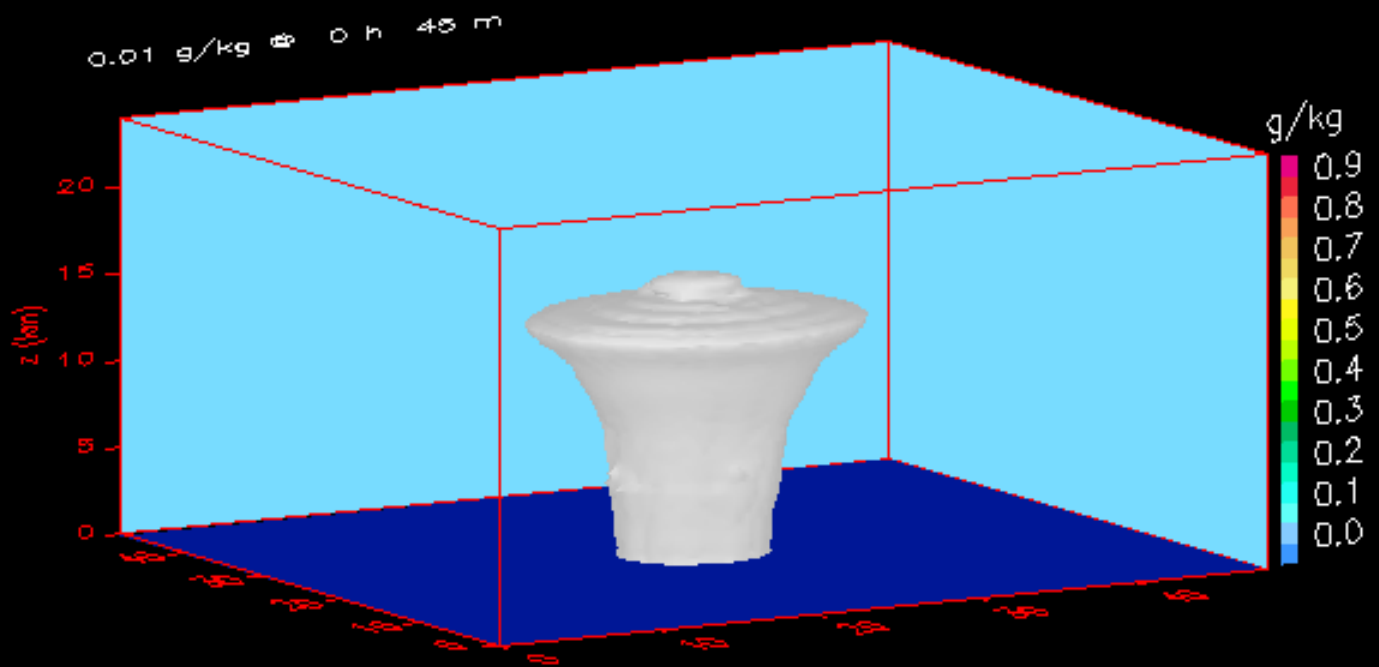
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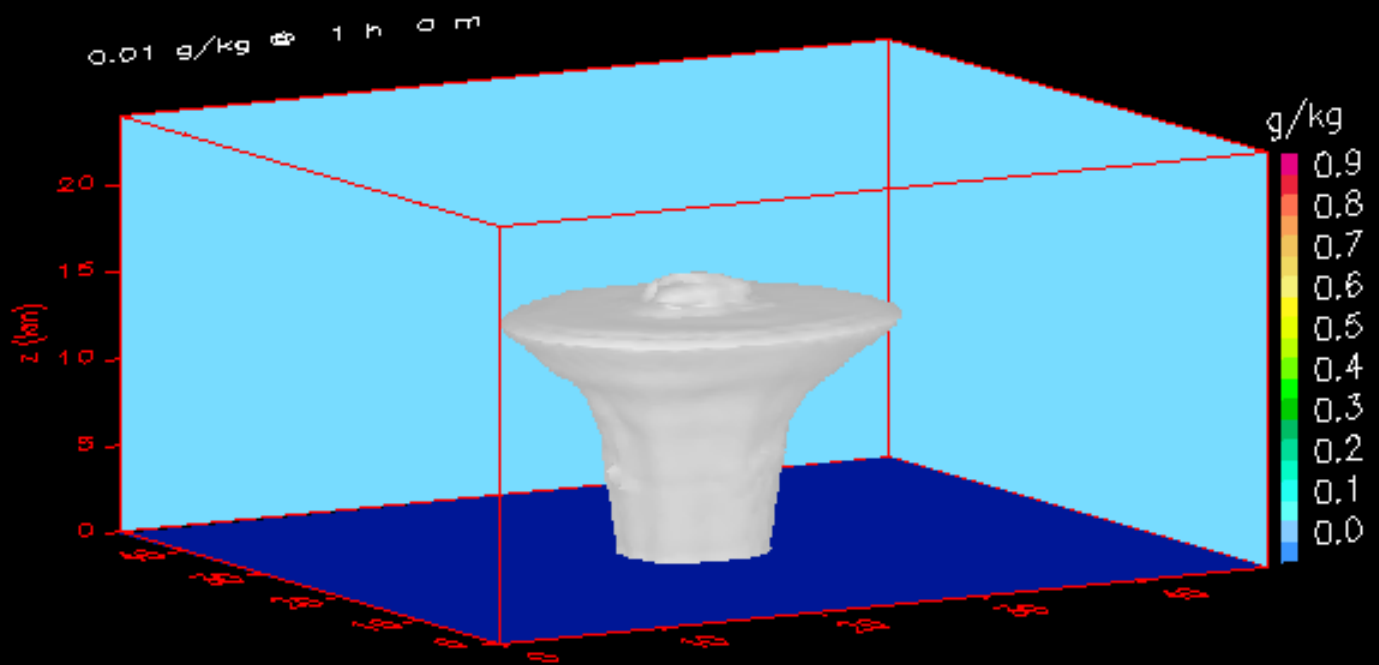
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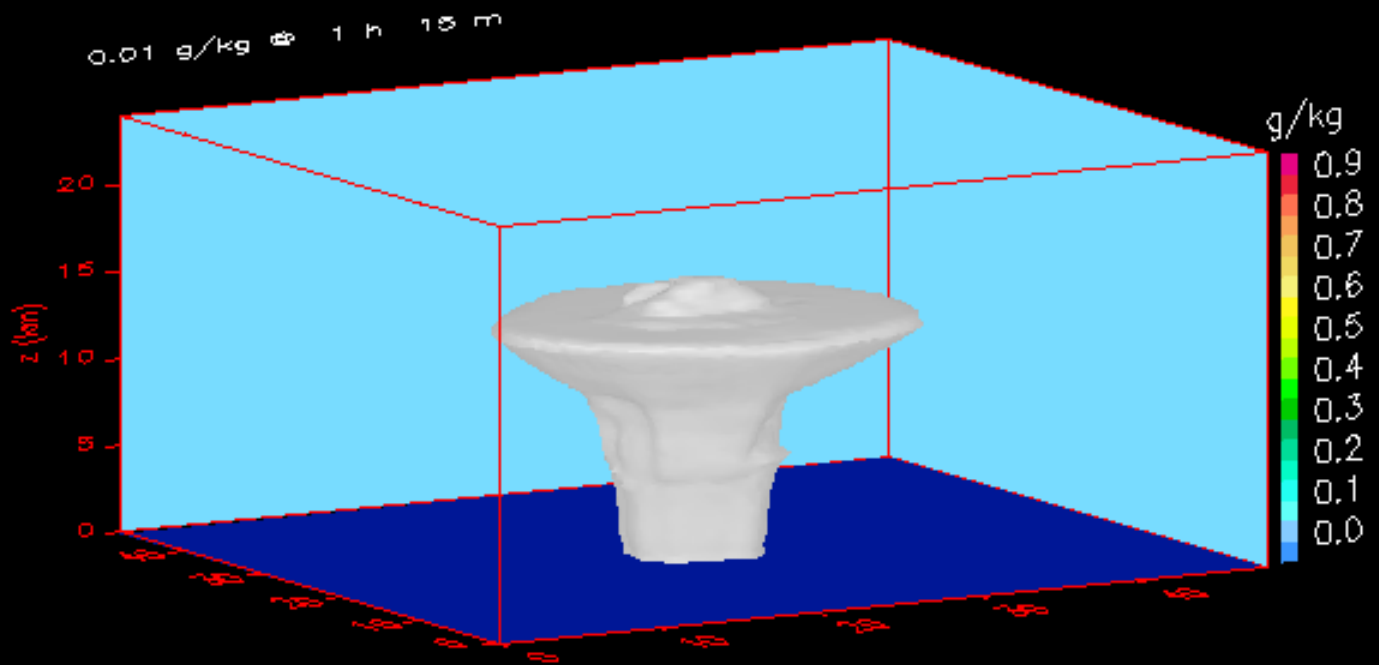


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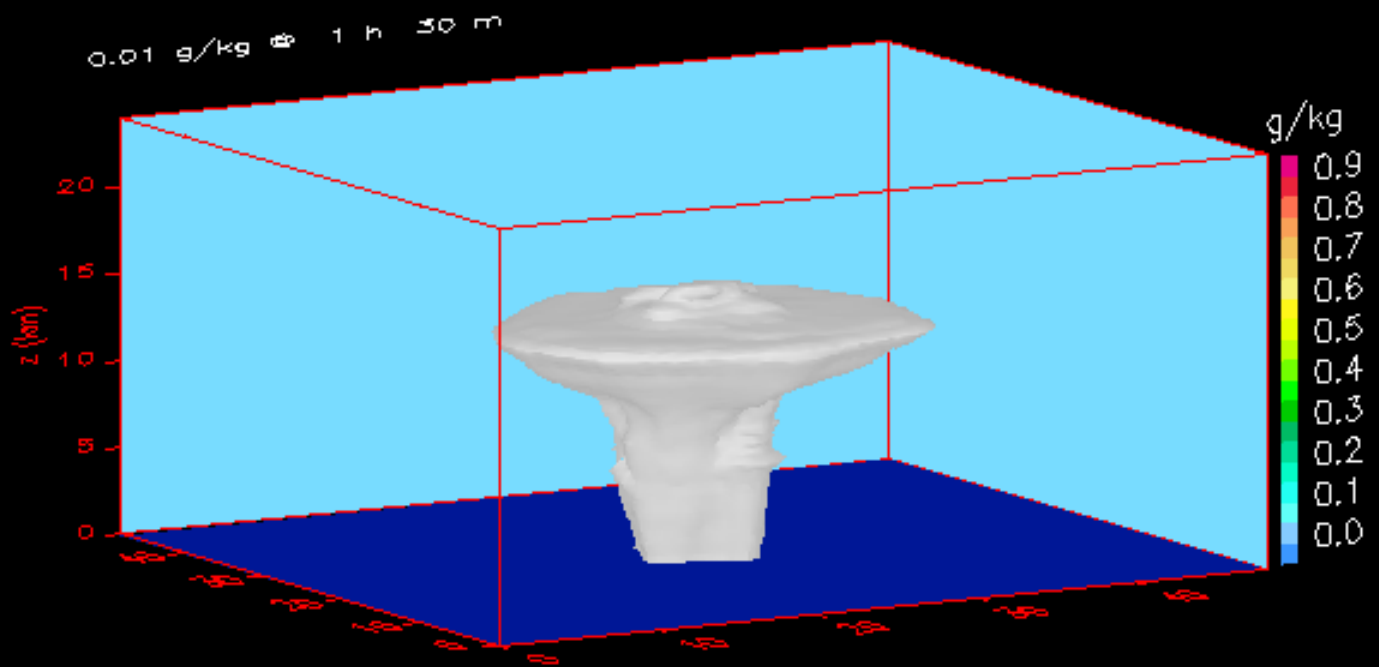




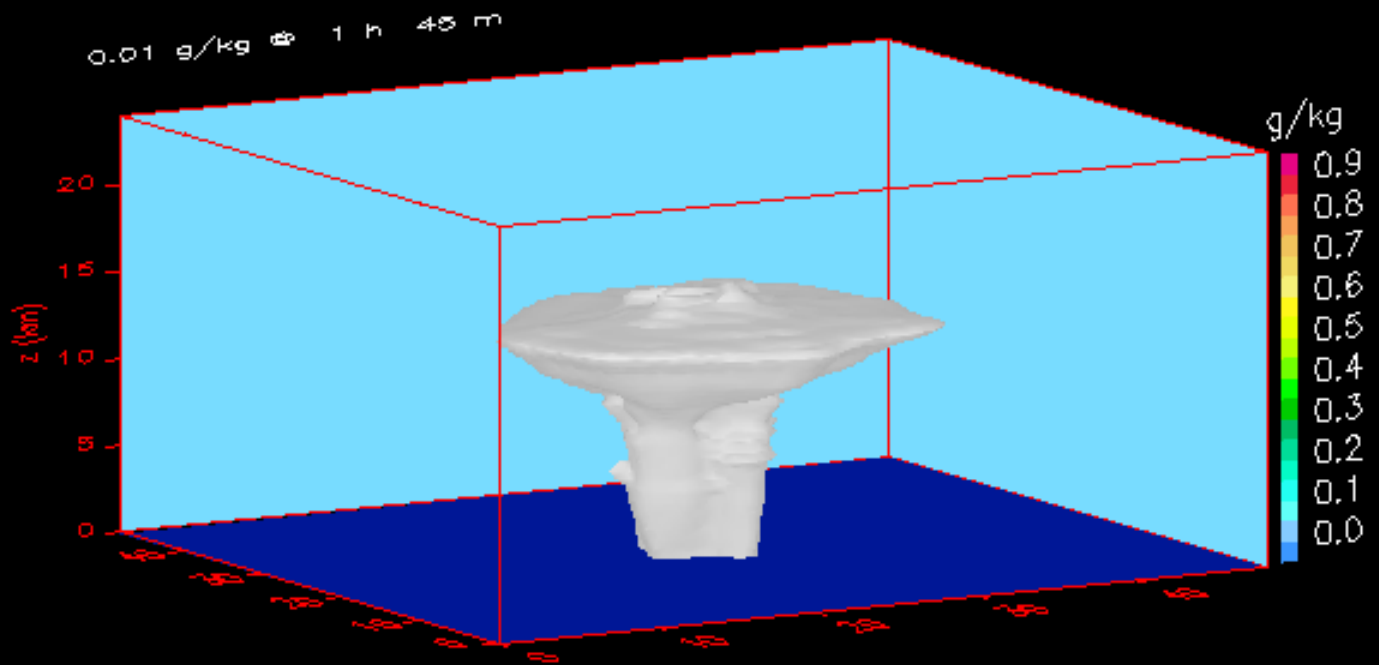
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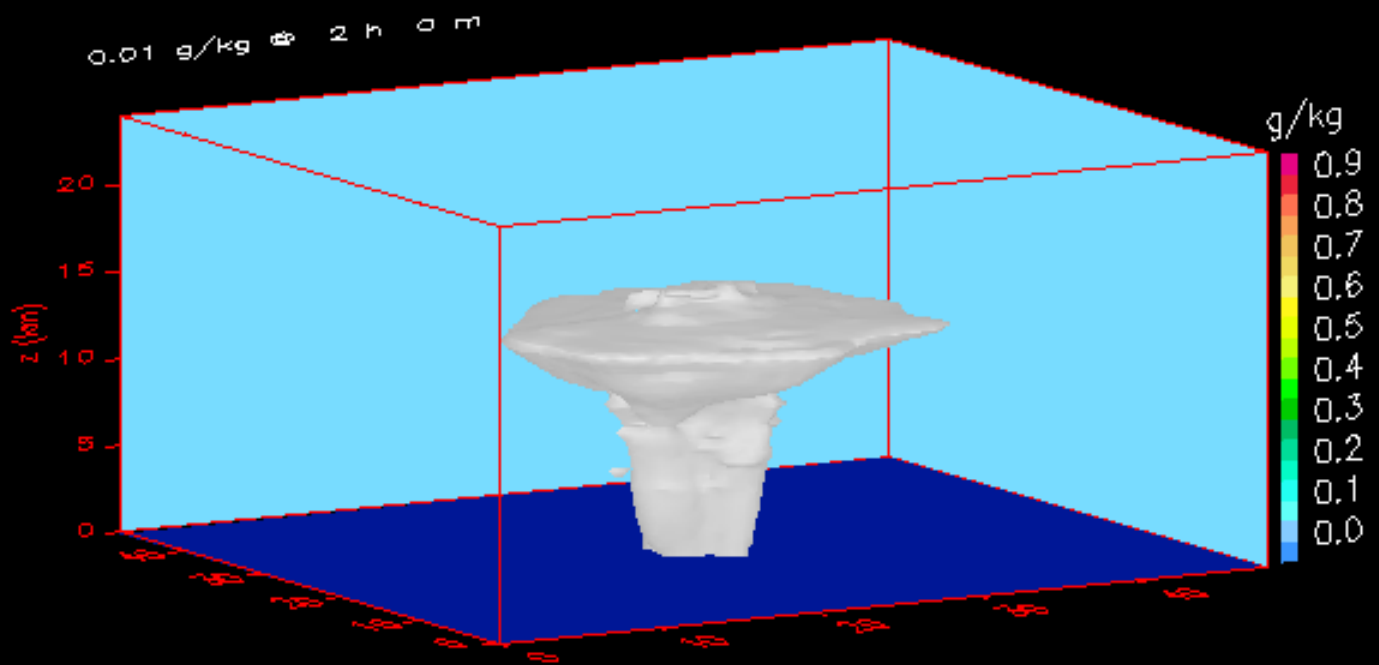
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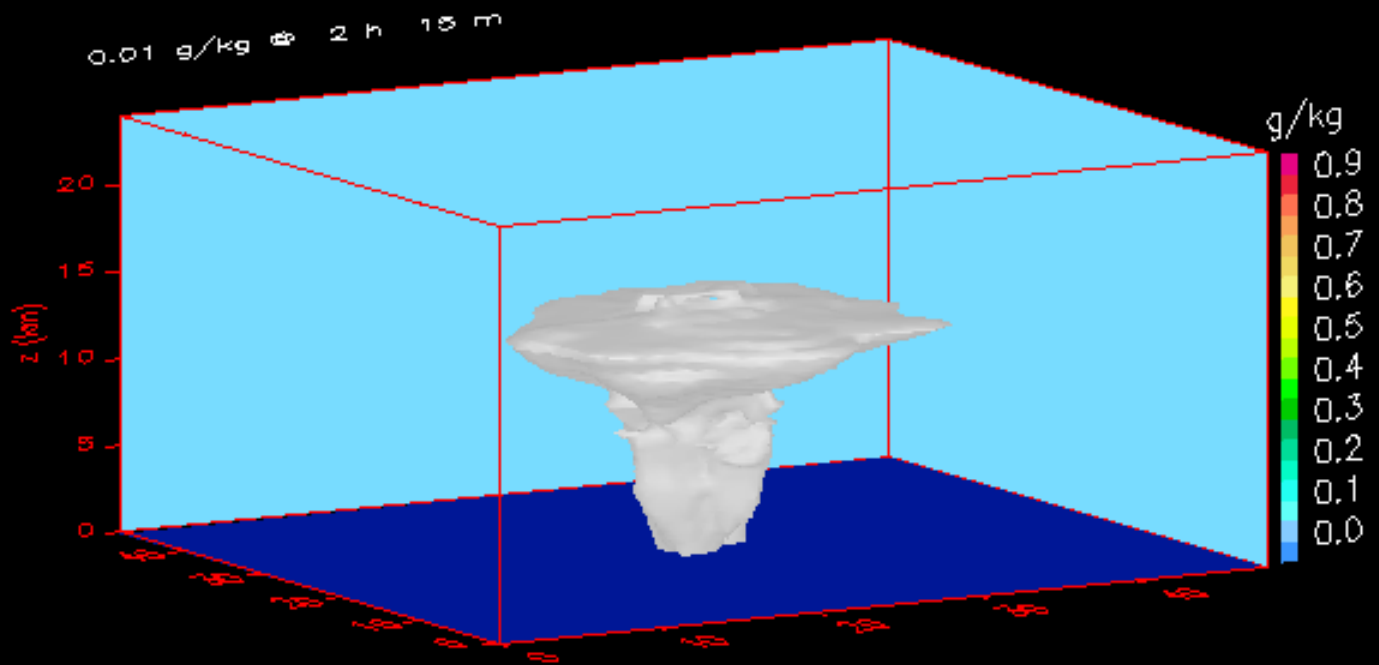
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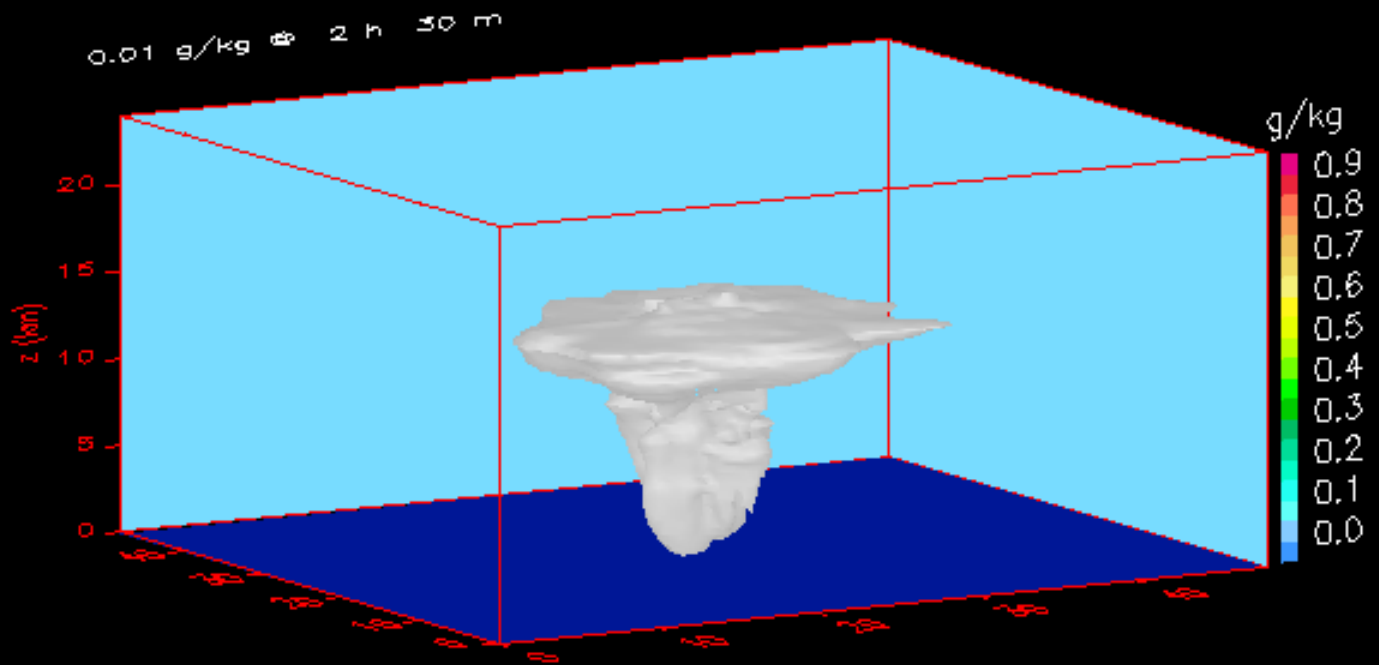
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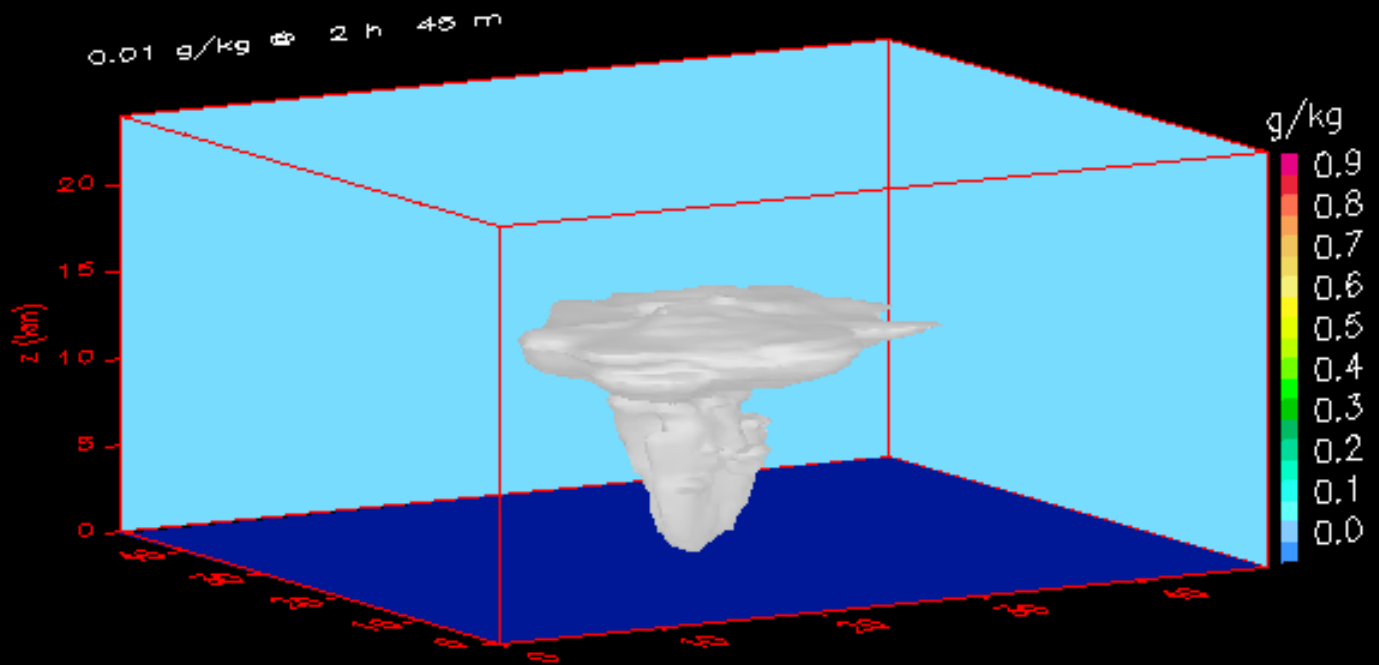
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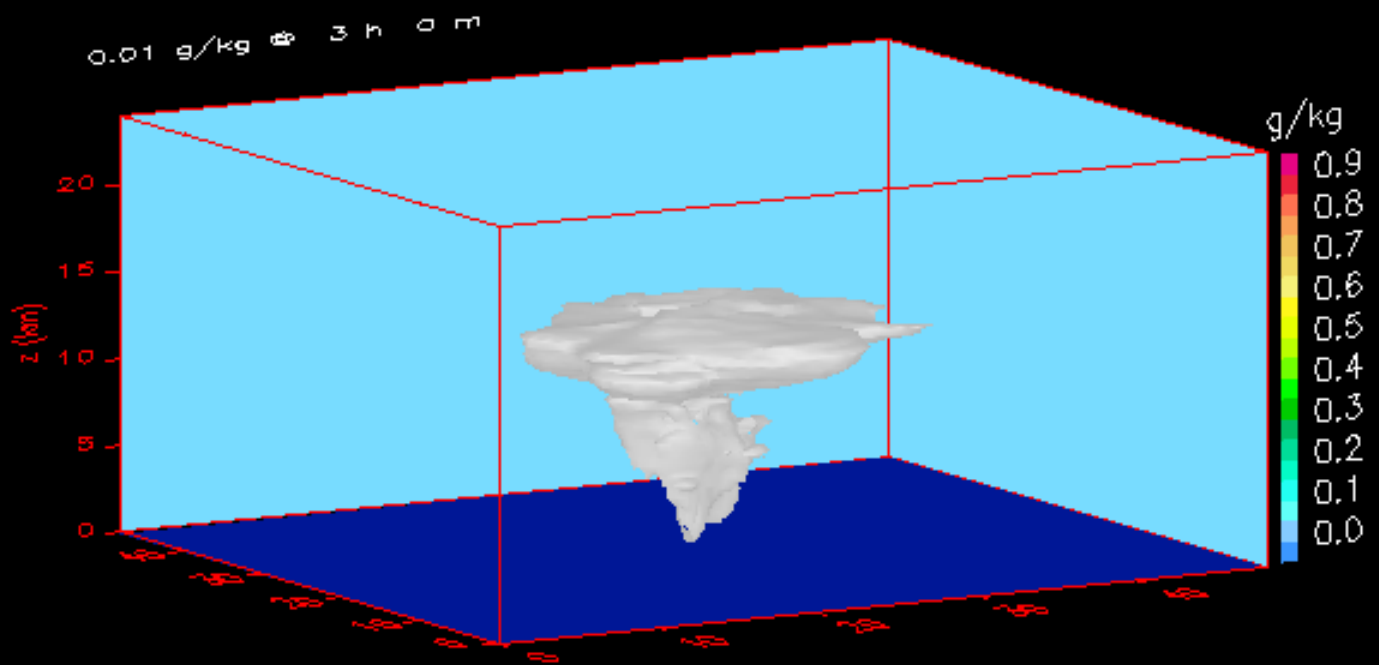
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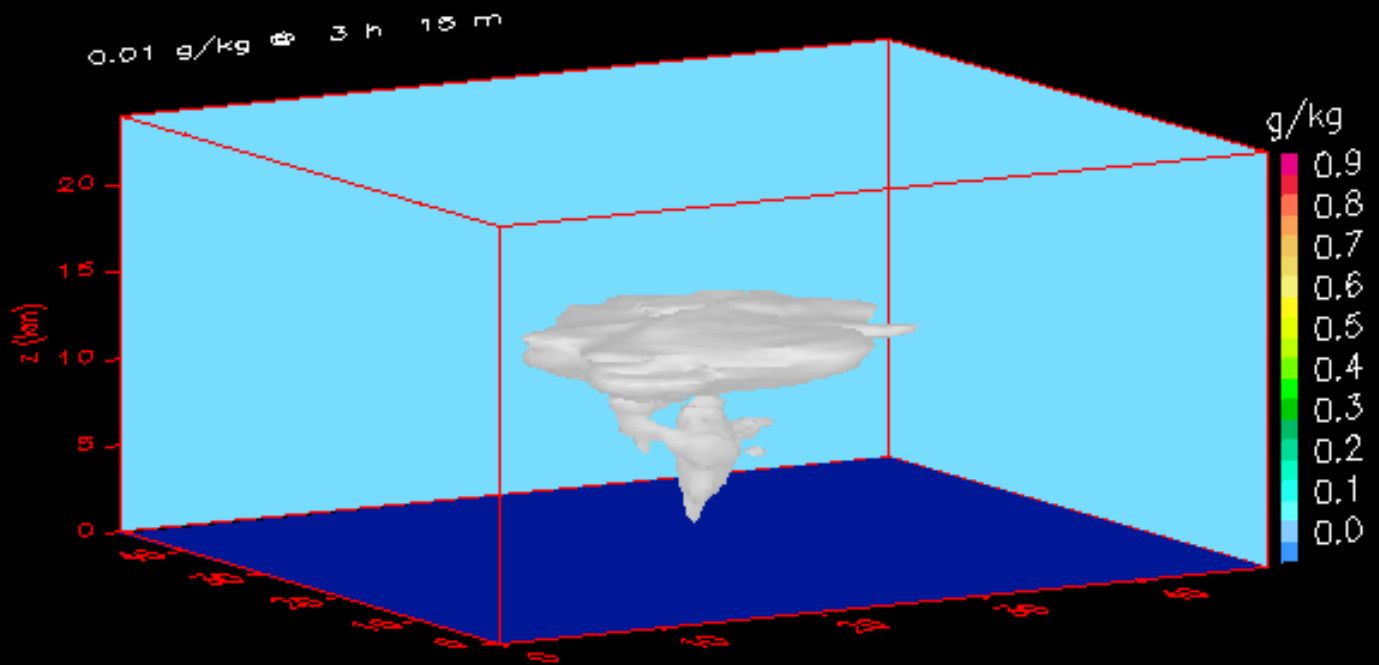


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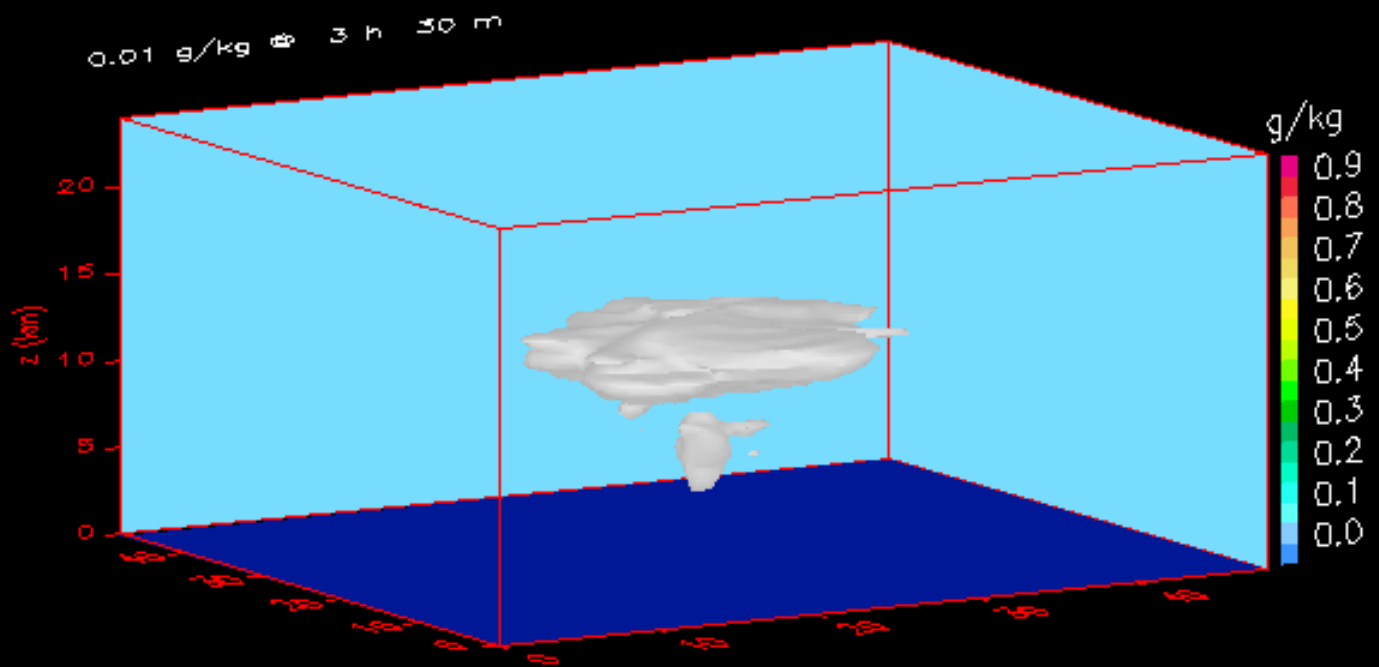




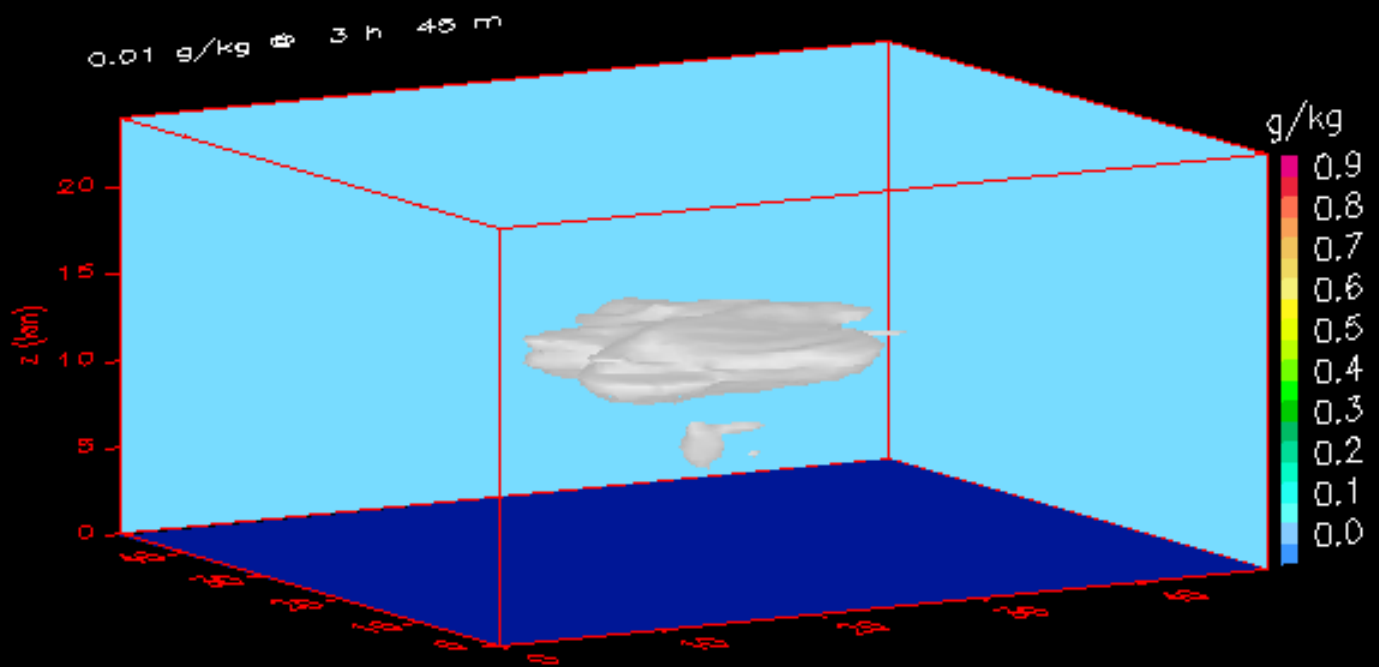
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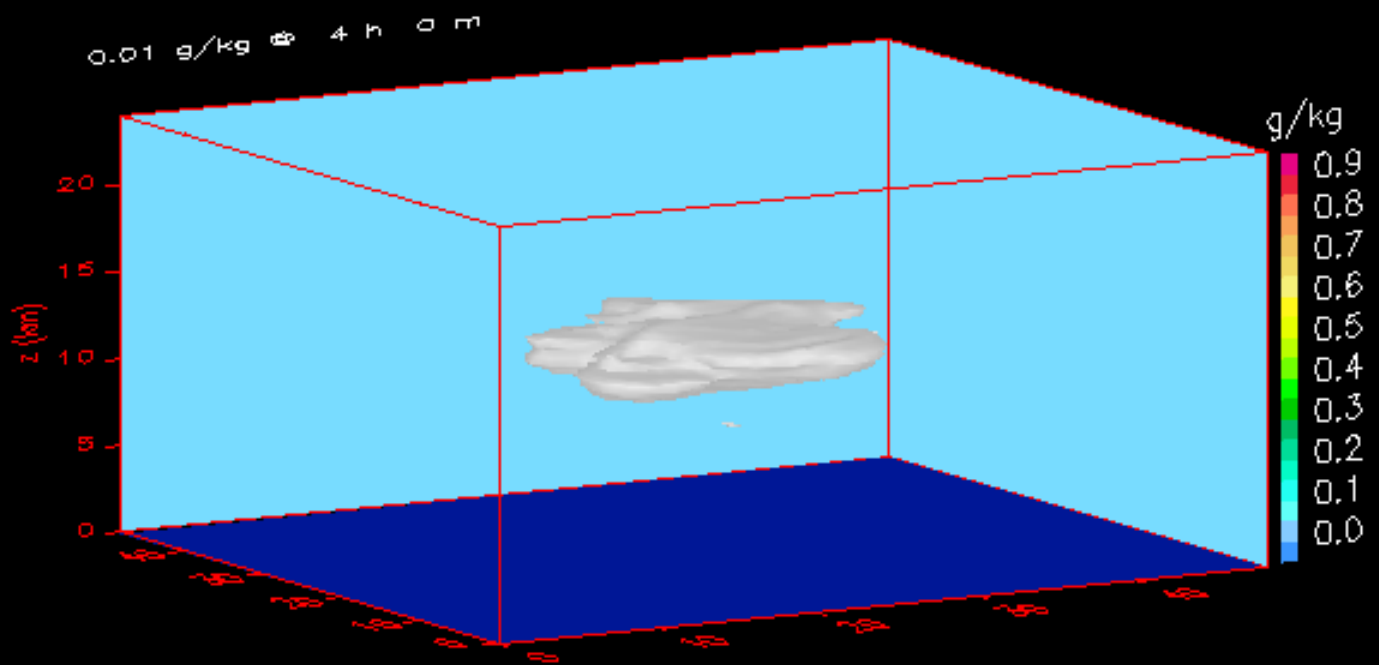
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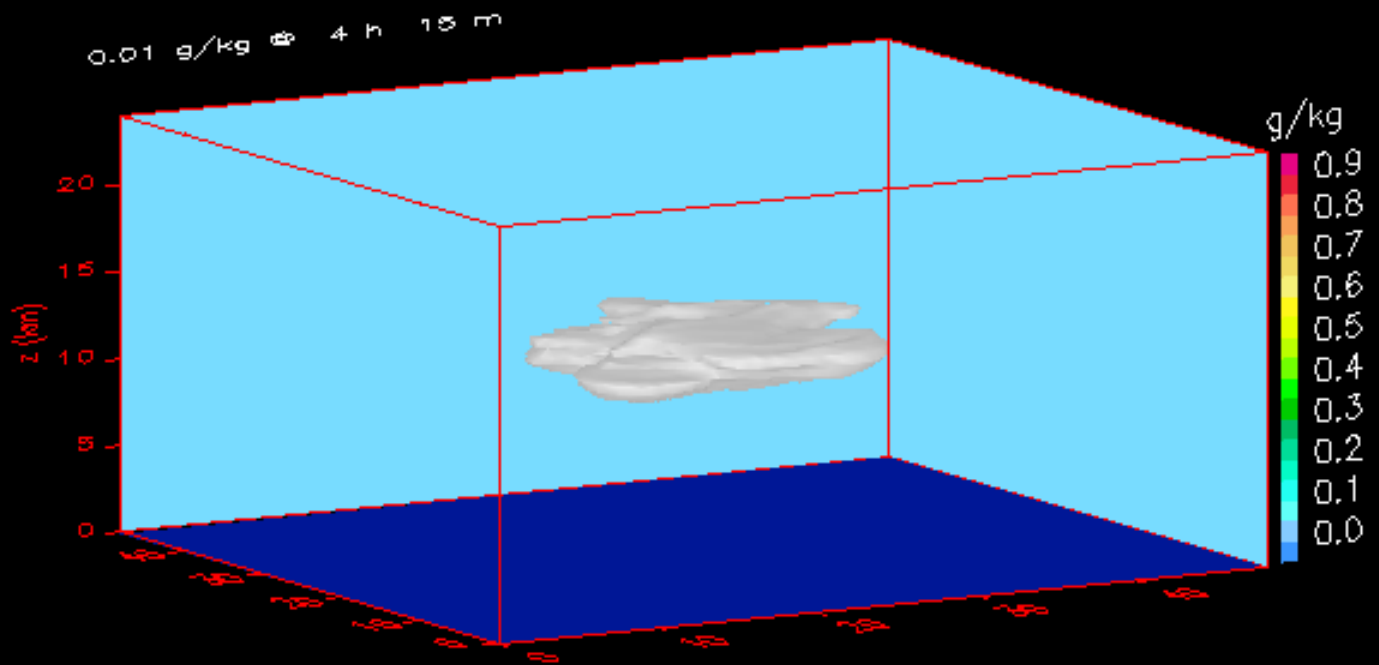
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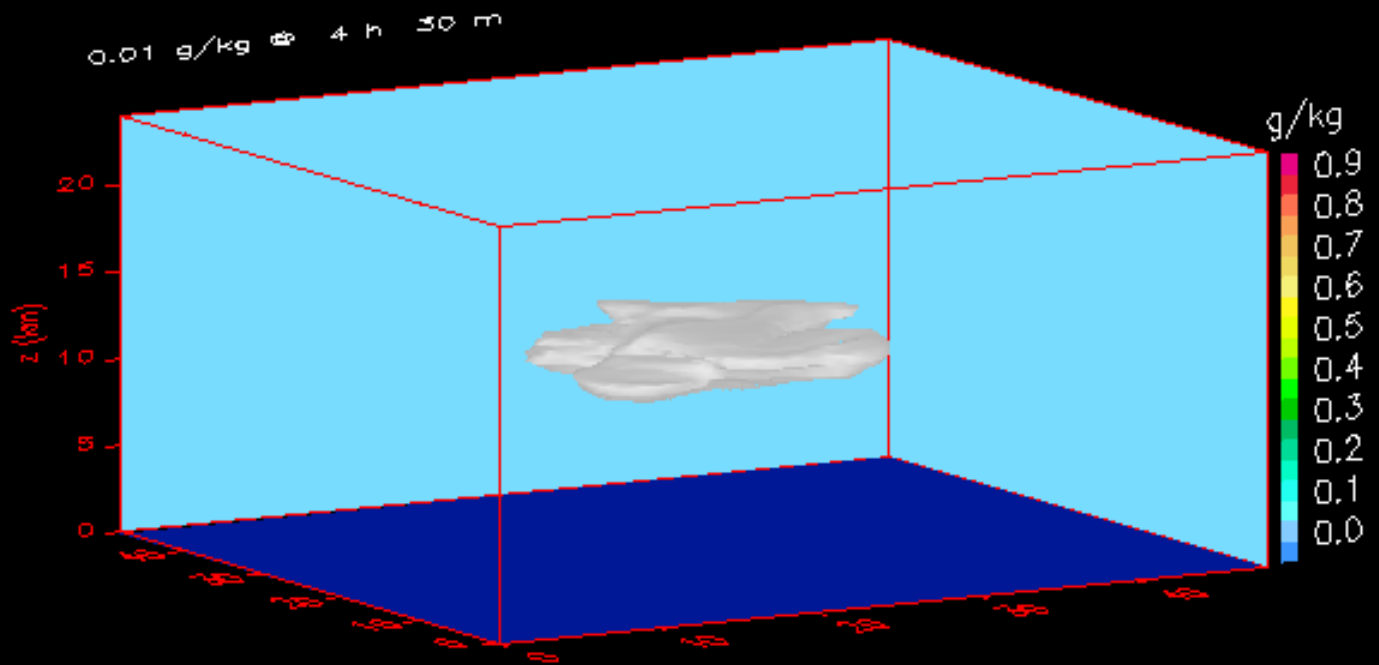
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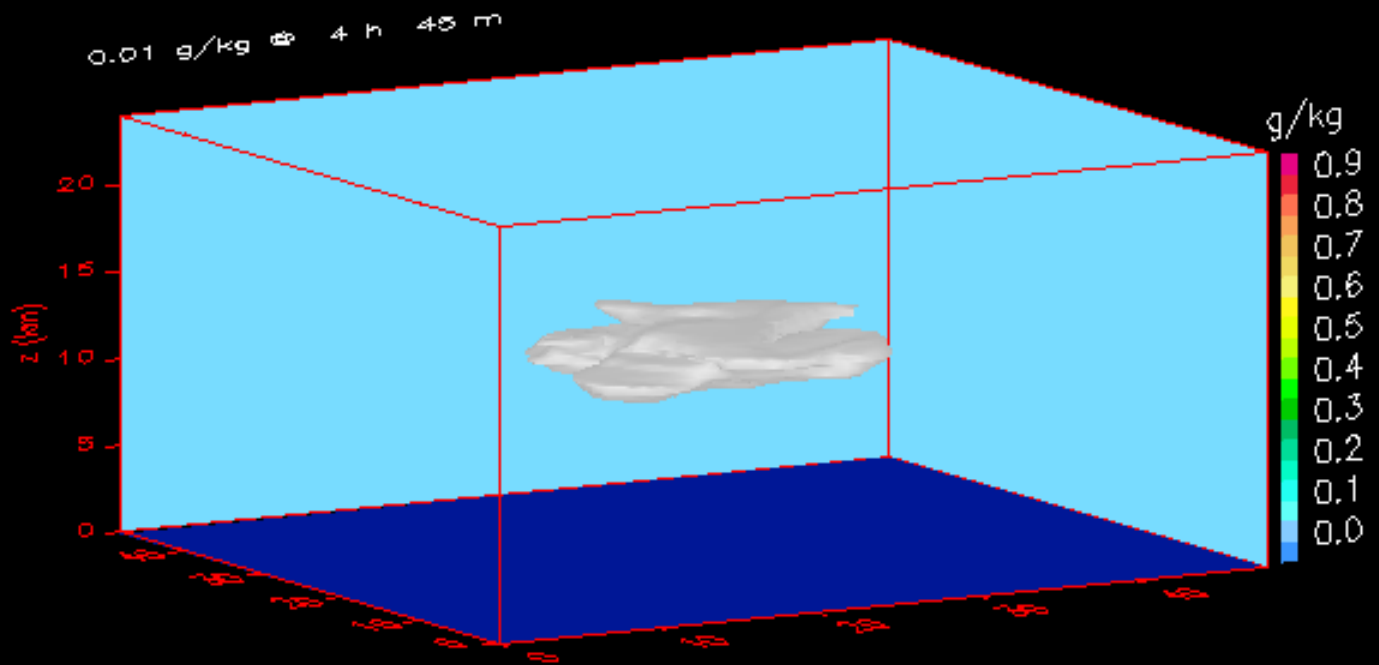
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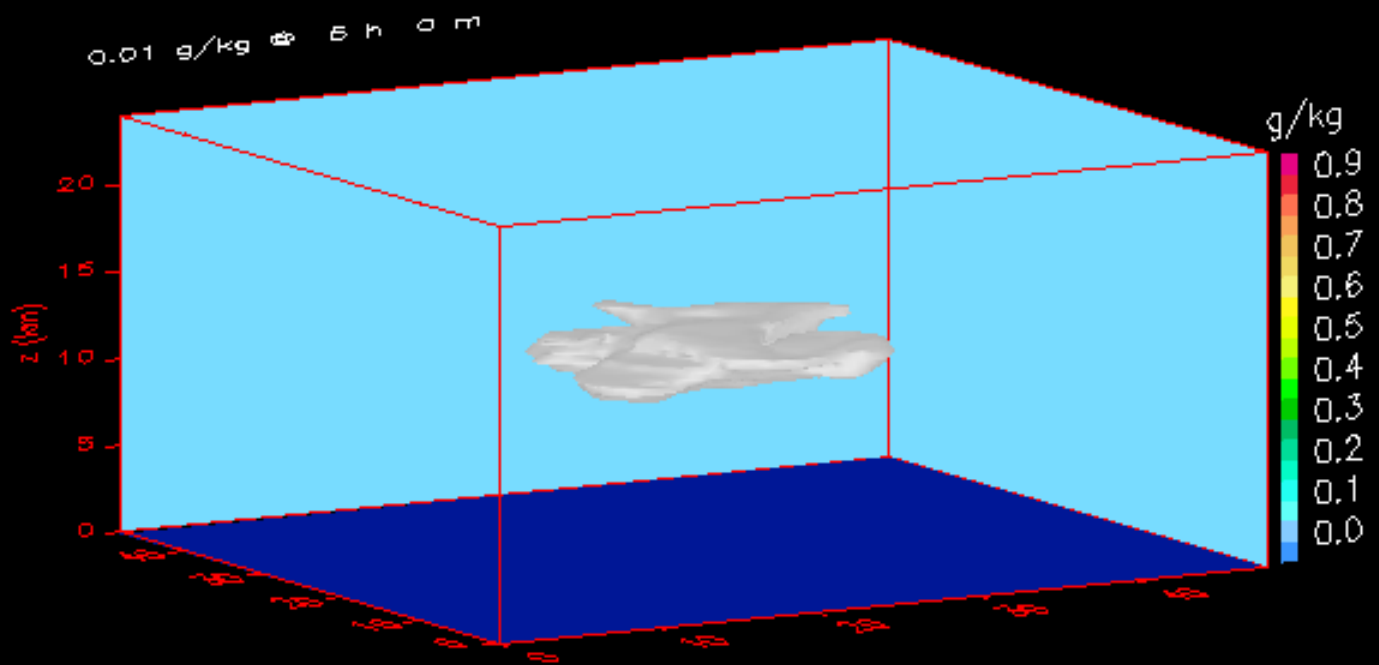
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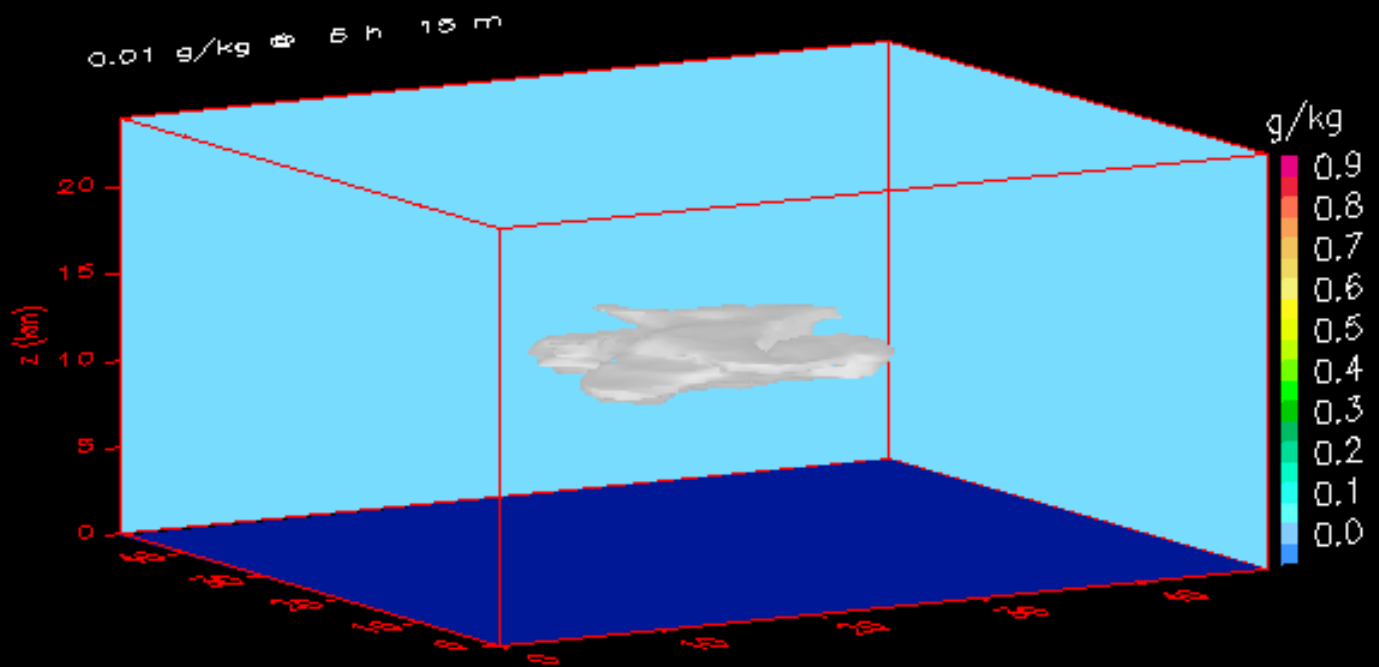


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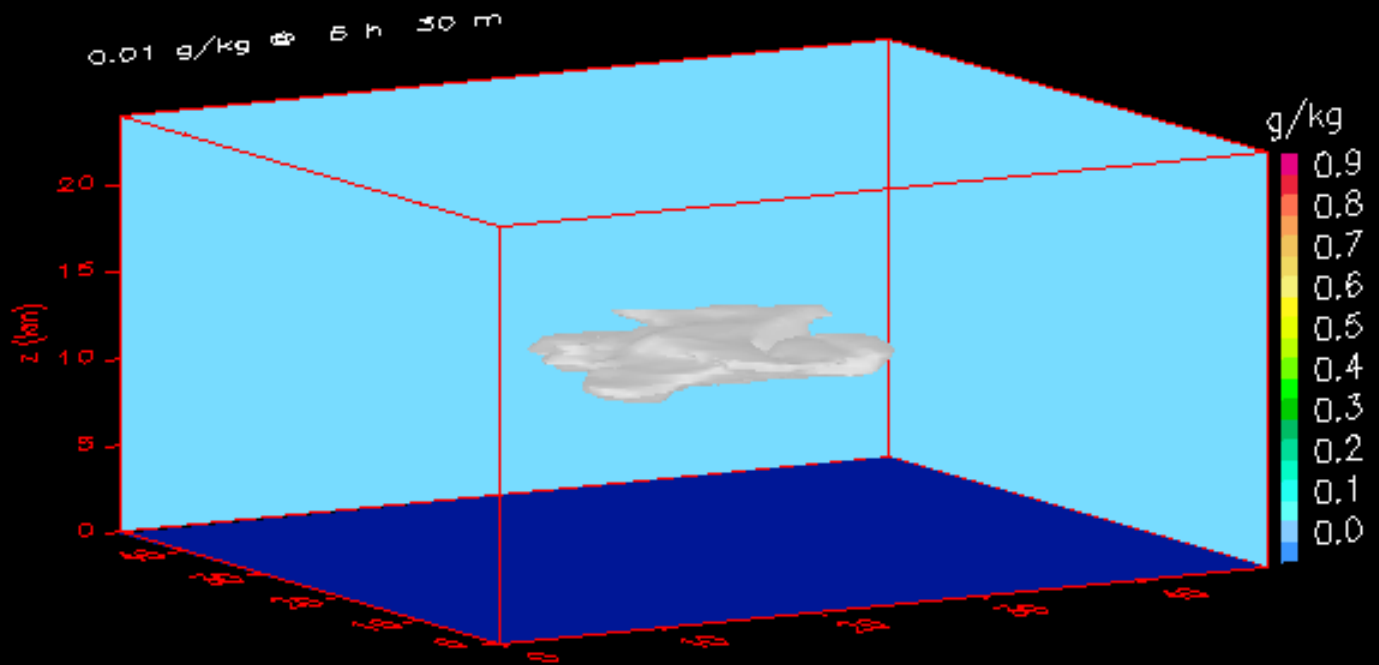




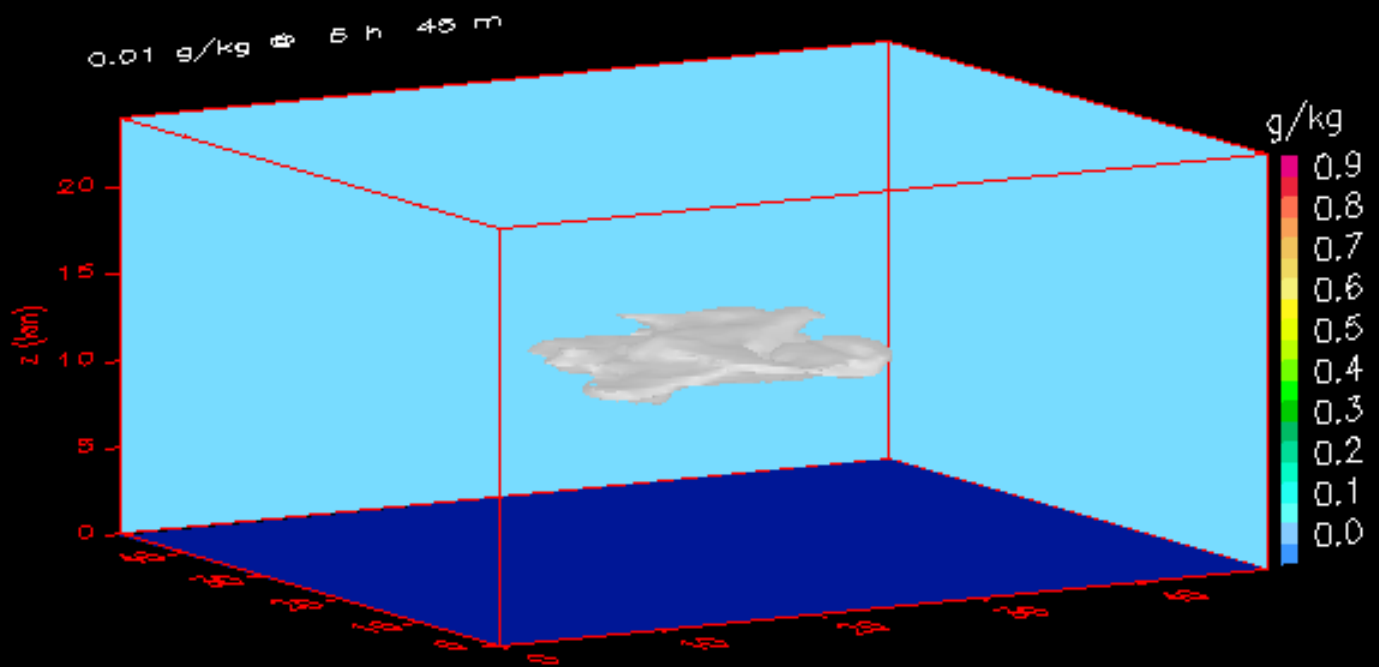
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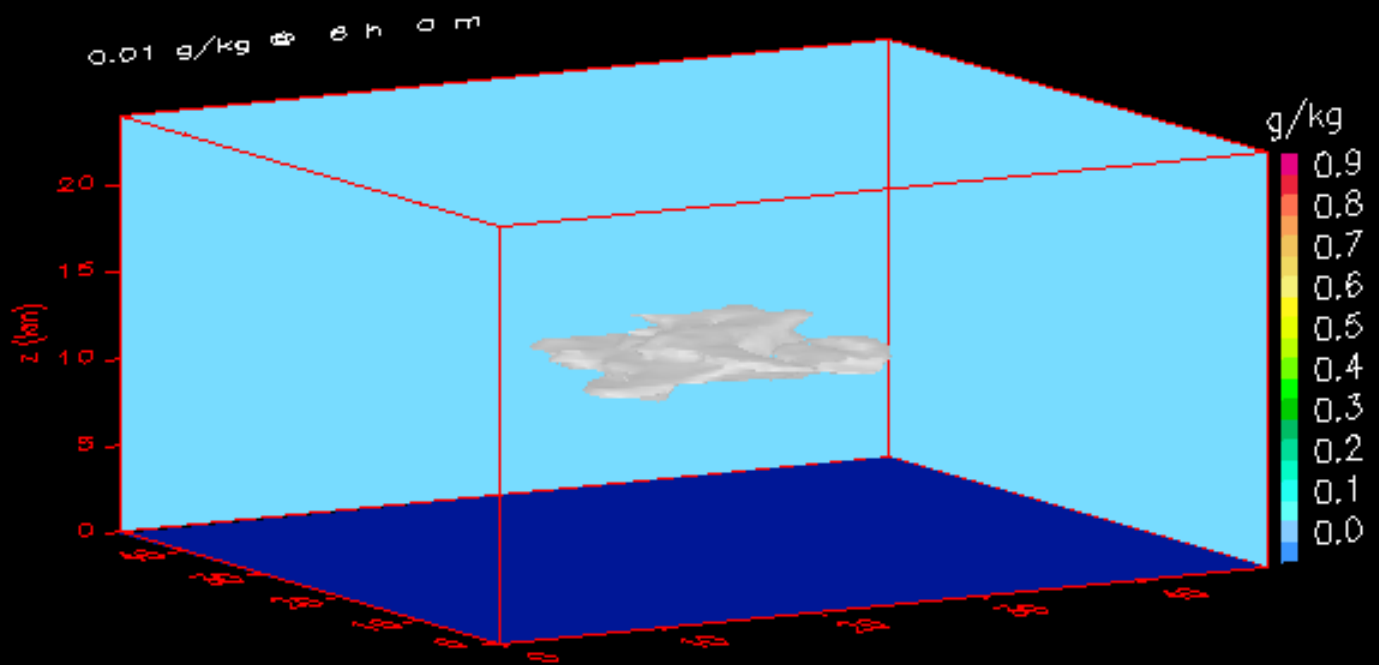
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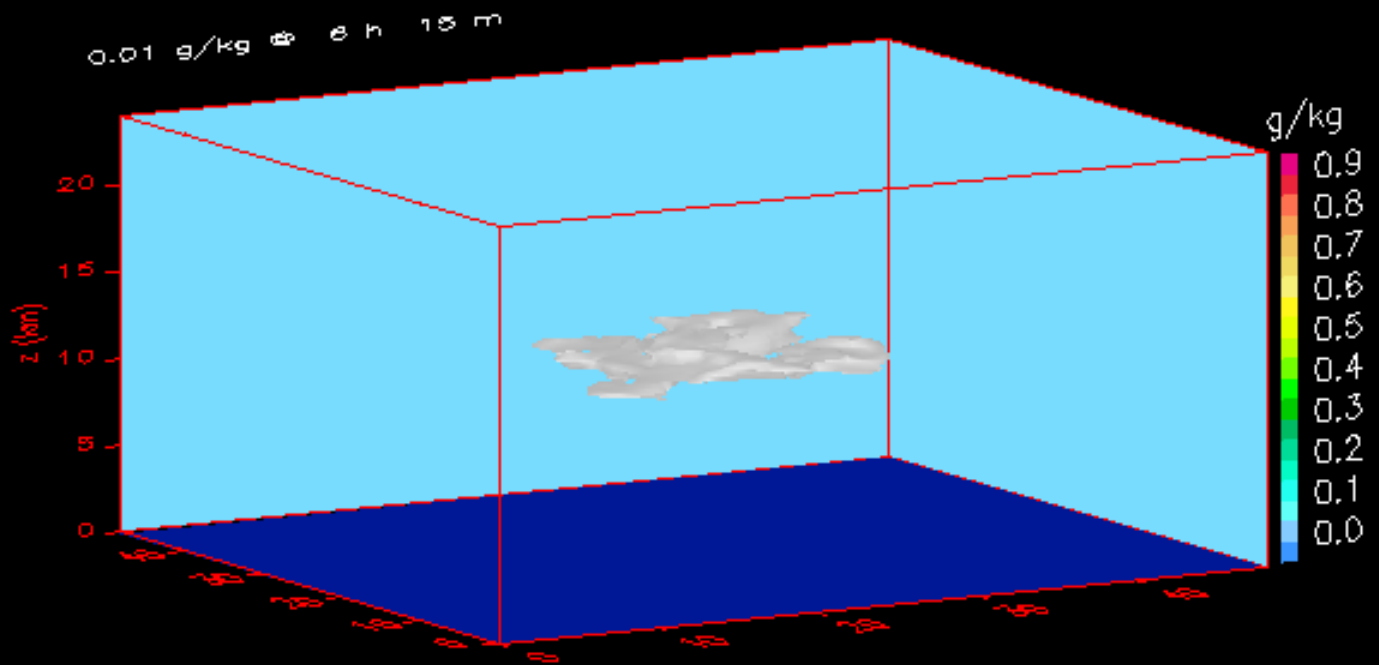
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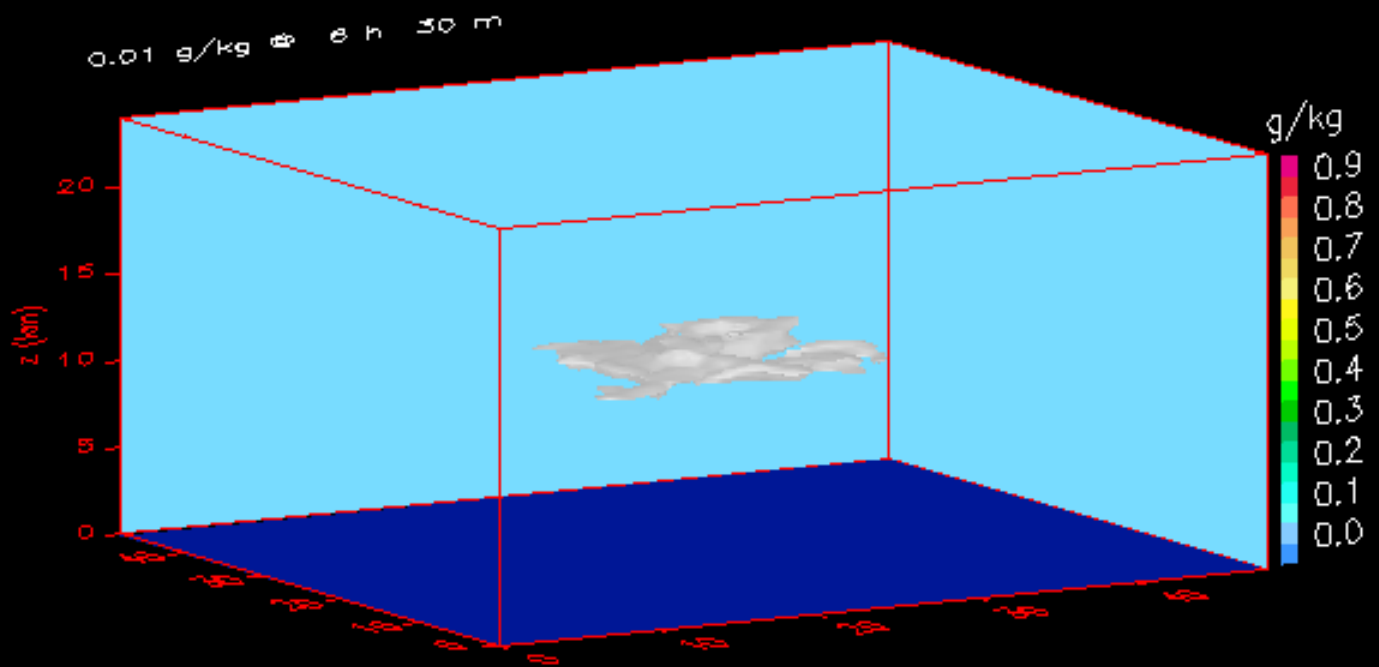
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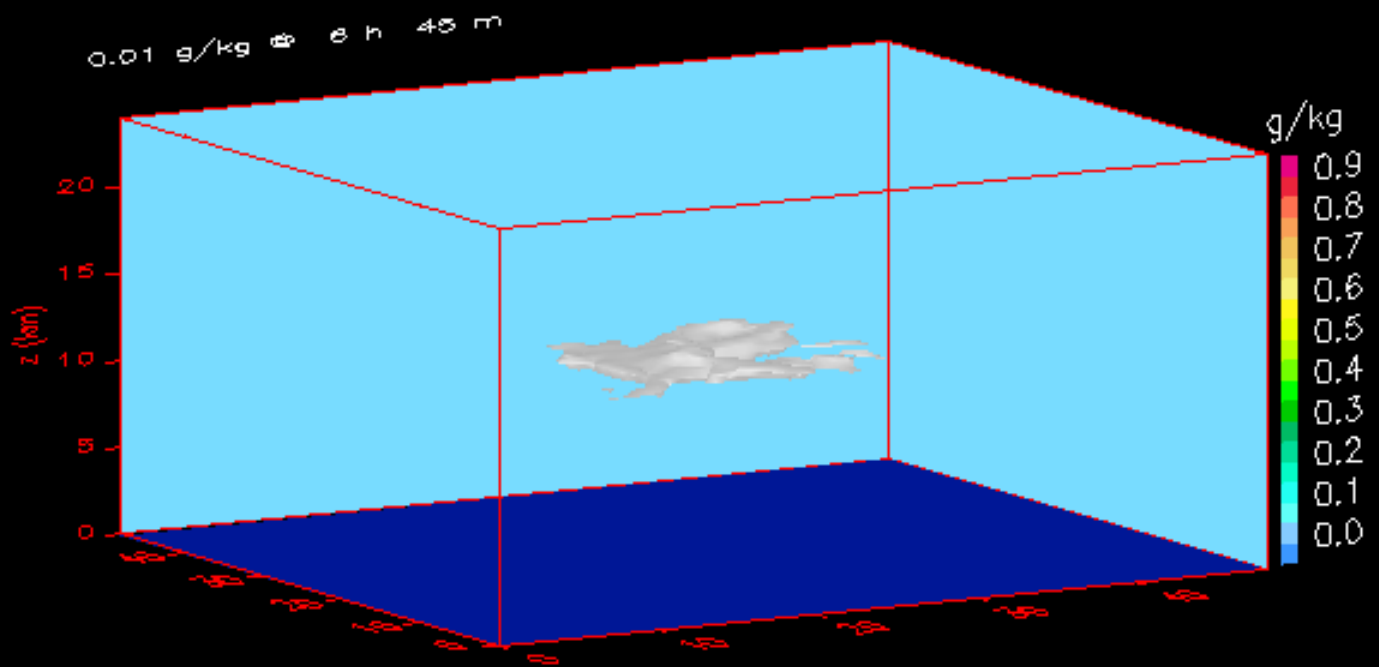
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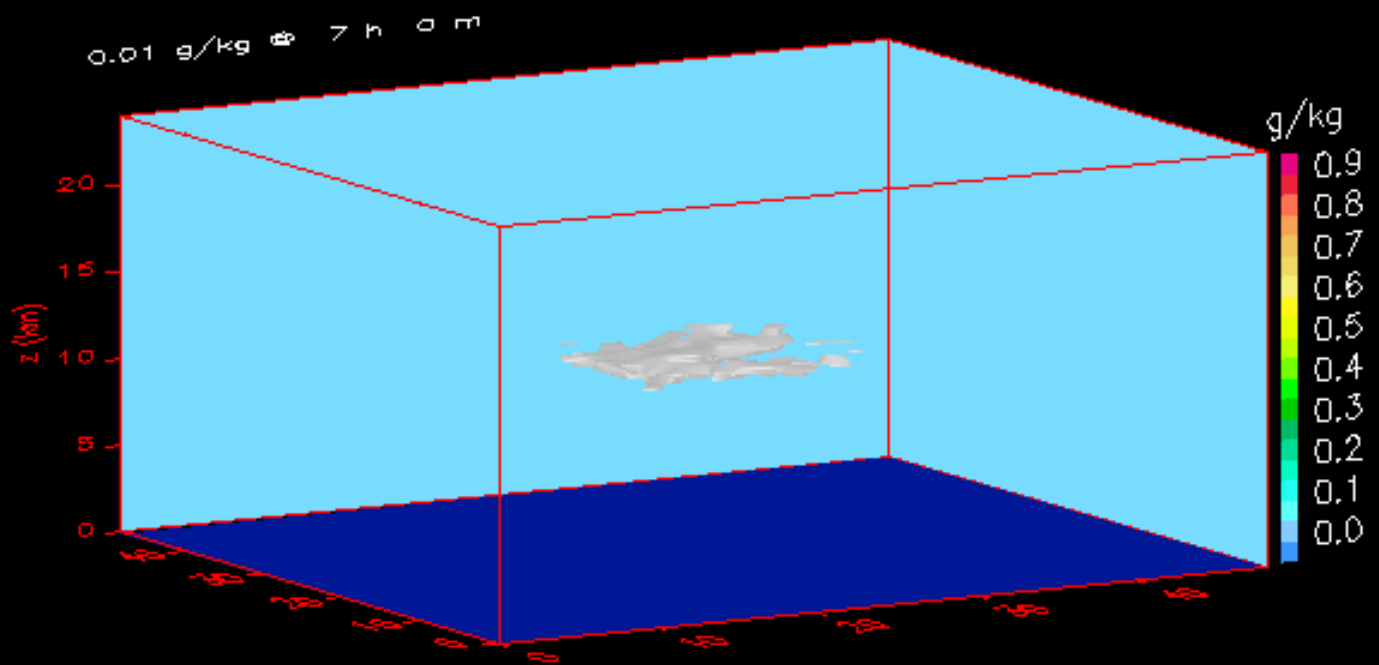
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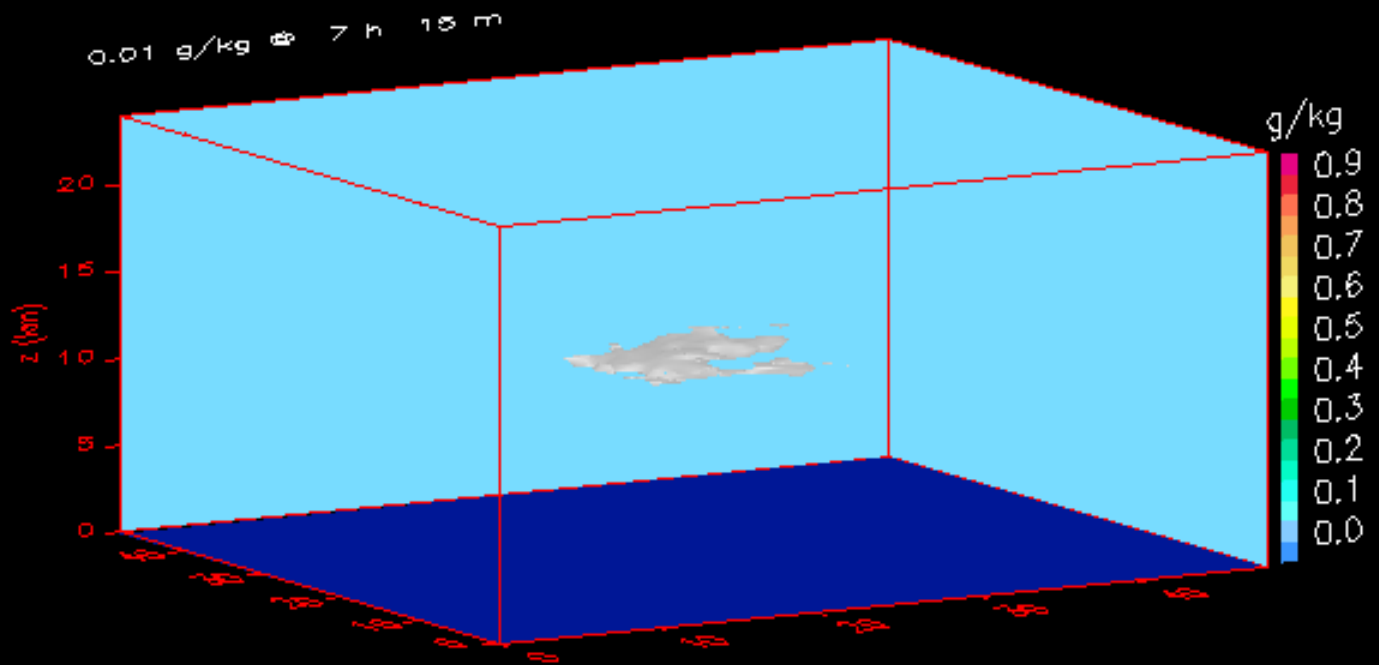


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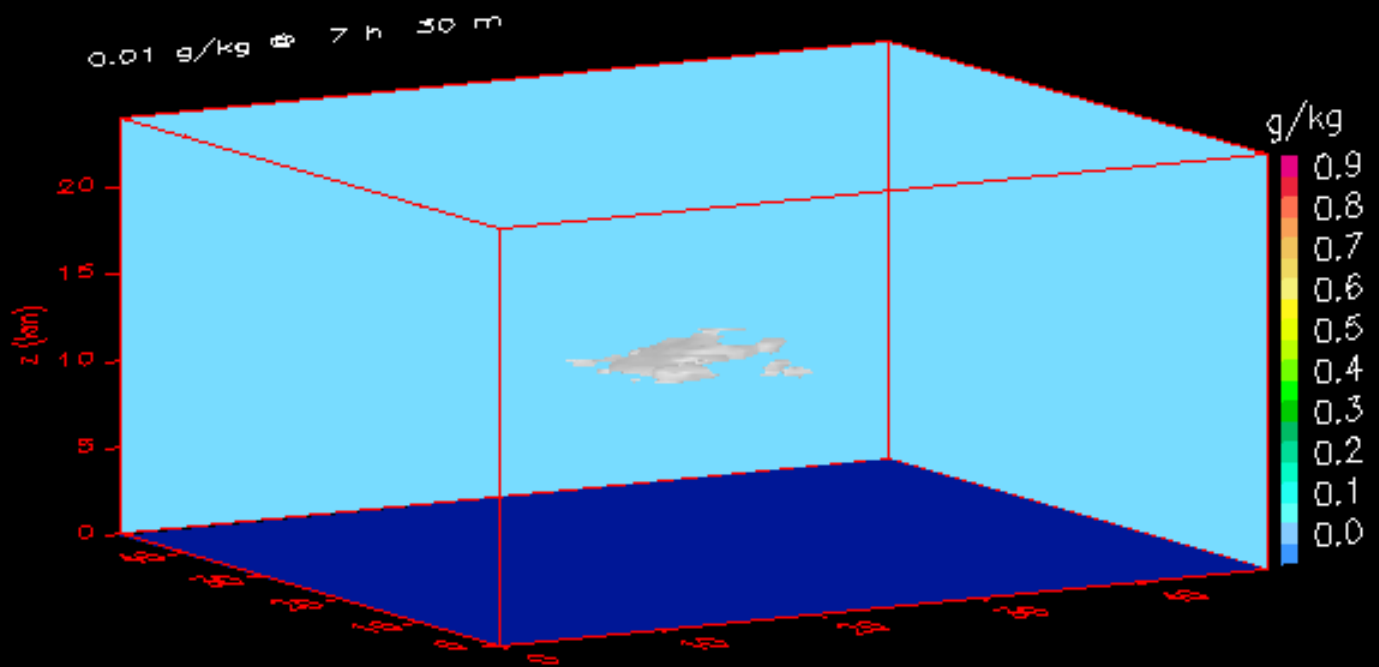




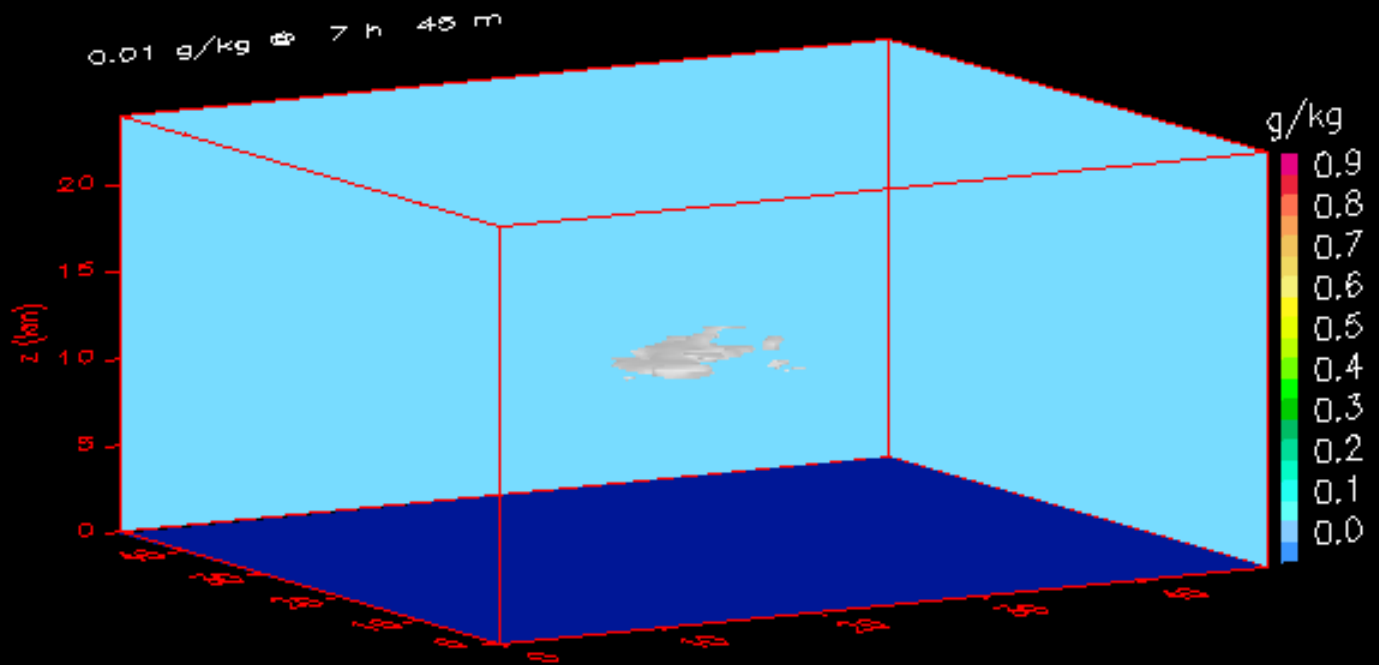
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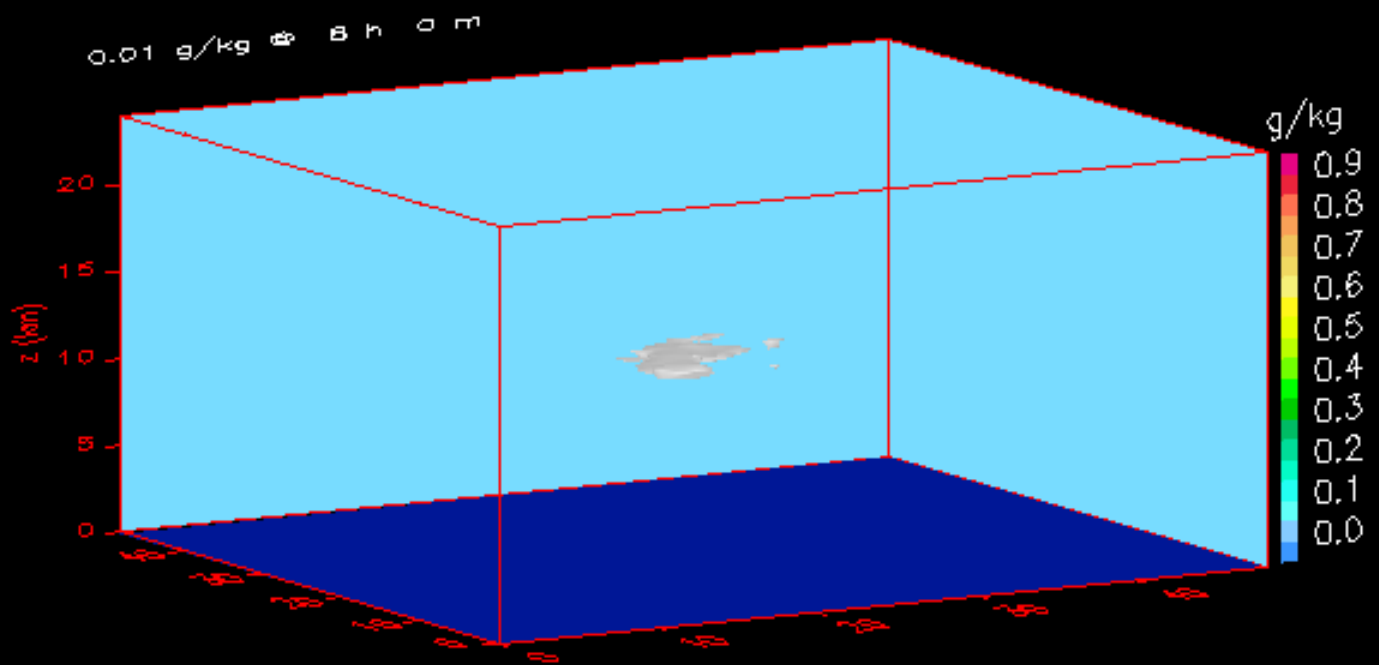
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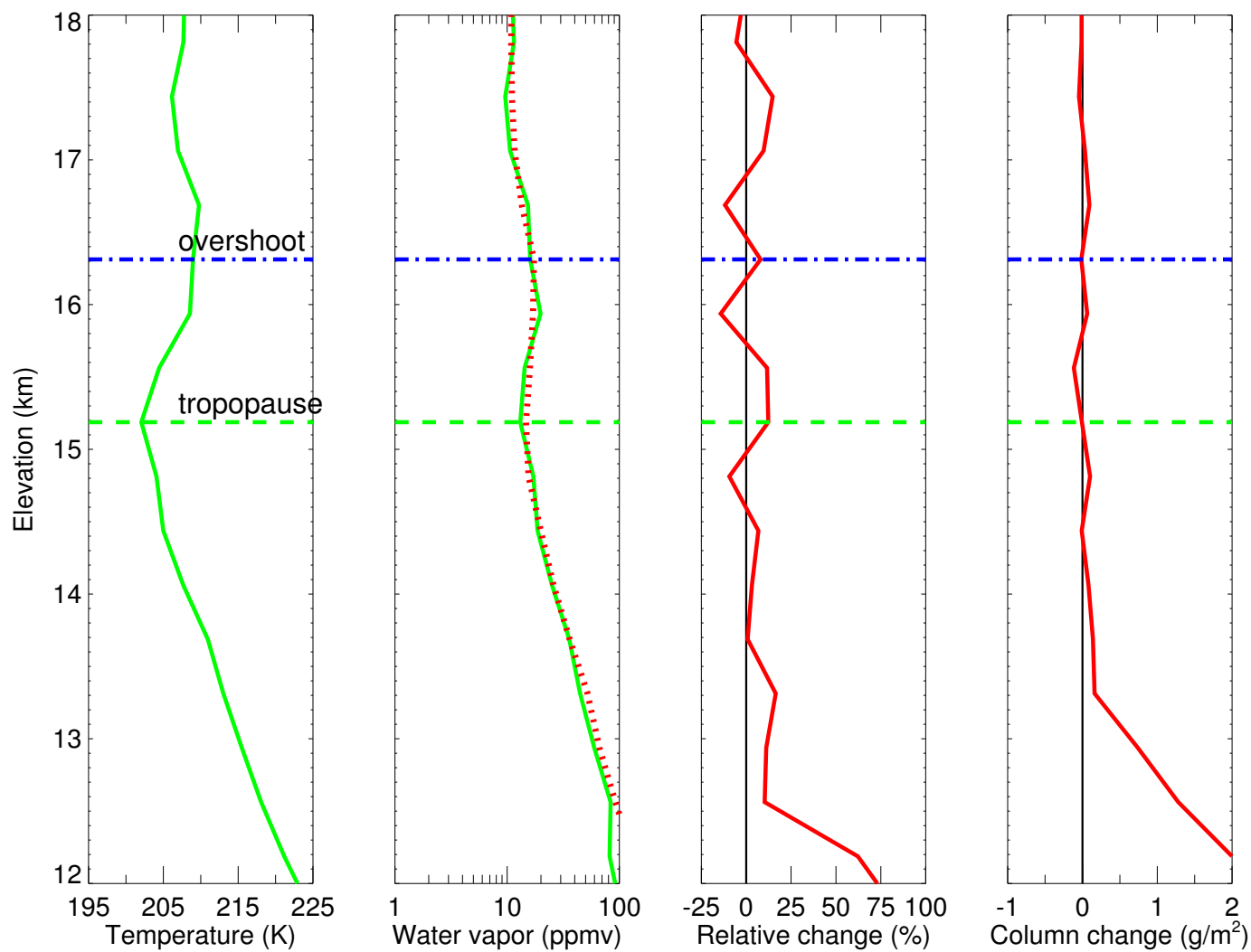
## **!!! NOTE !!!**

In the conversion from water vapor mass mixing ratio (as used by the model) to volume mixing ratio (as shown in the following plots) a mistake was made that resulted in the humidities being a factor of 4 smaller (as shown in the Utah presentation) than was actually measured.

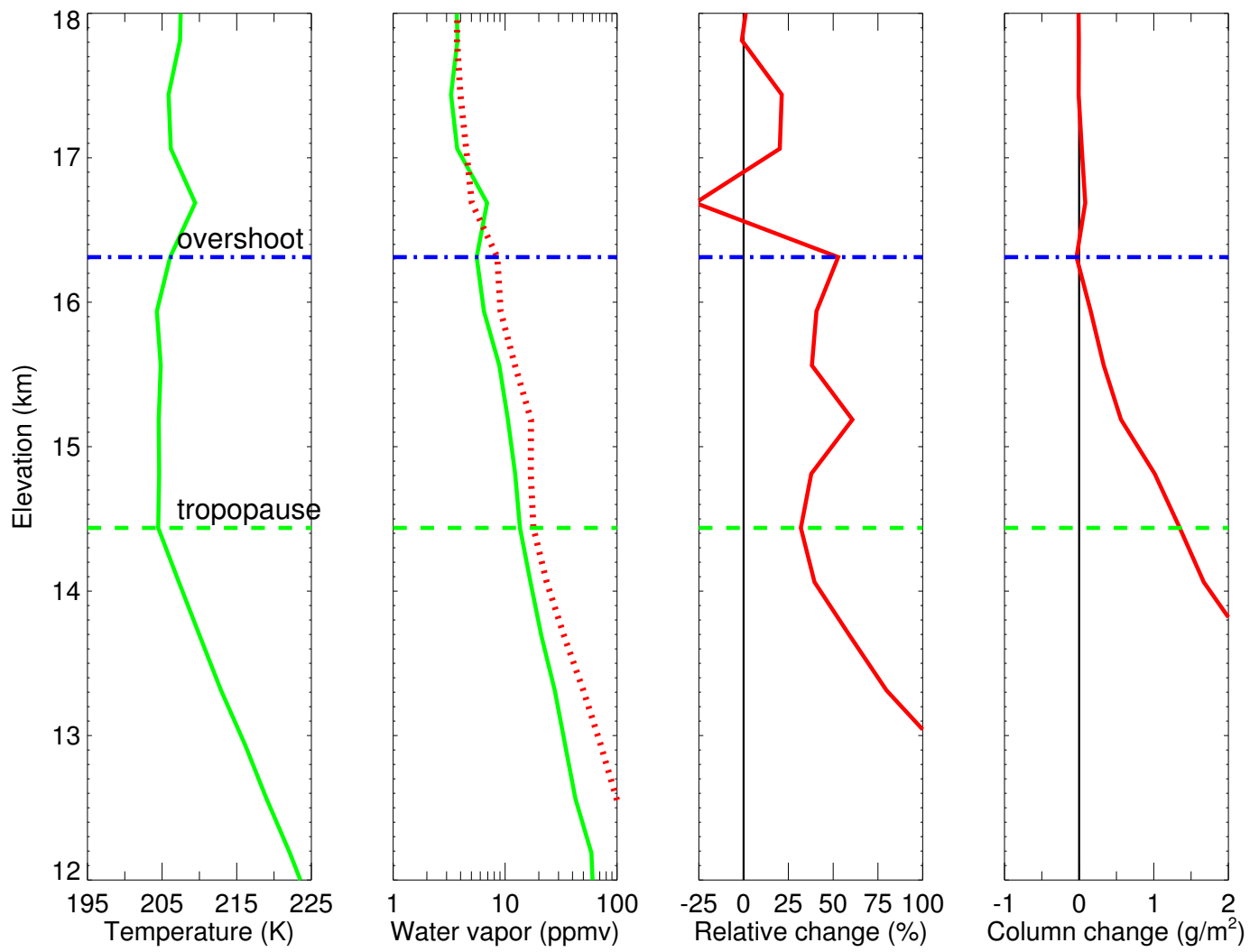
This was only a plotting error -- the correct values were used in the model simulations.

The error has been corrected in this version of the plots.

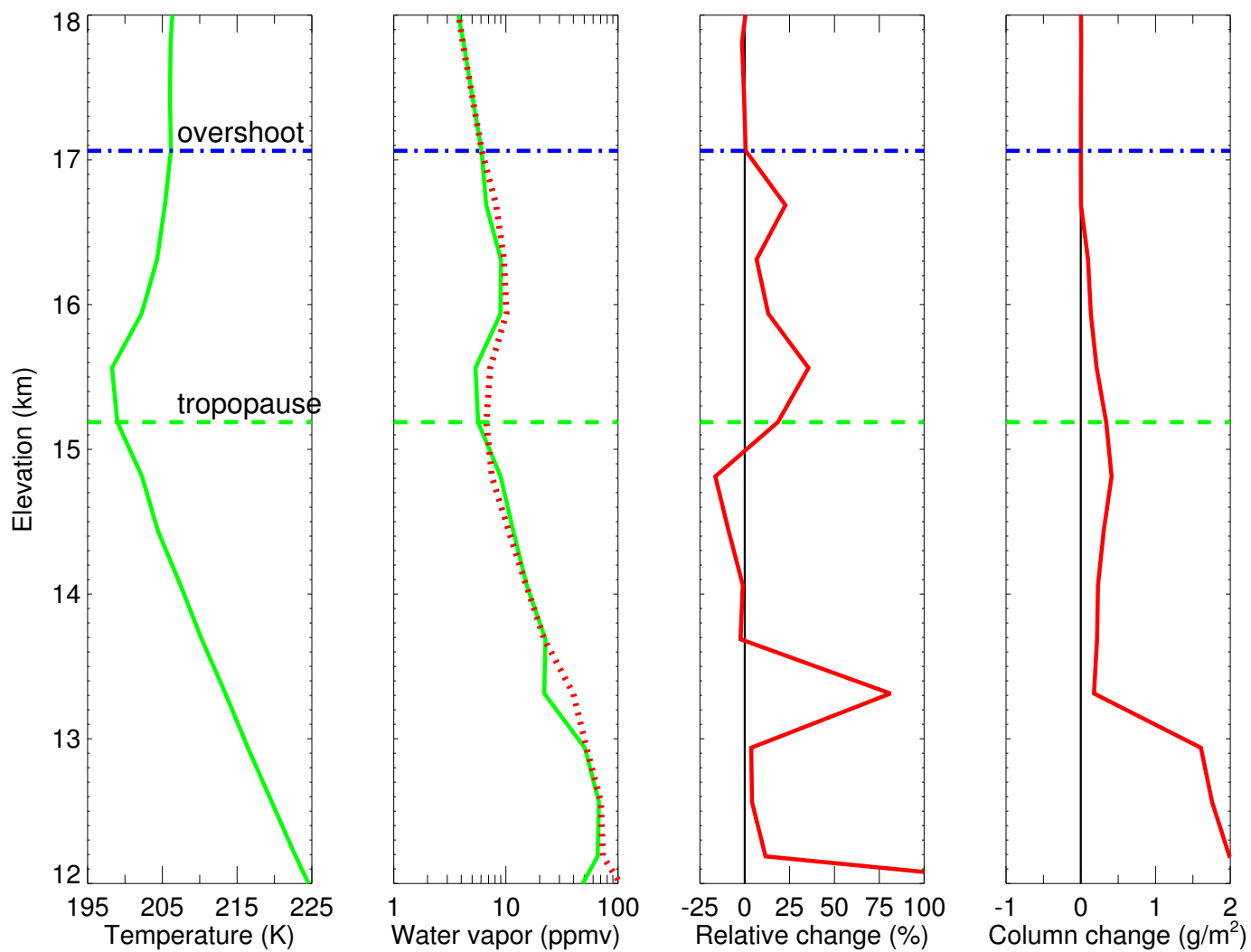
# July\_11\_Miami



# July\_11\_PARSL

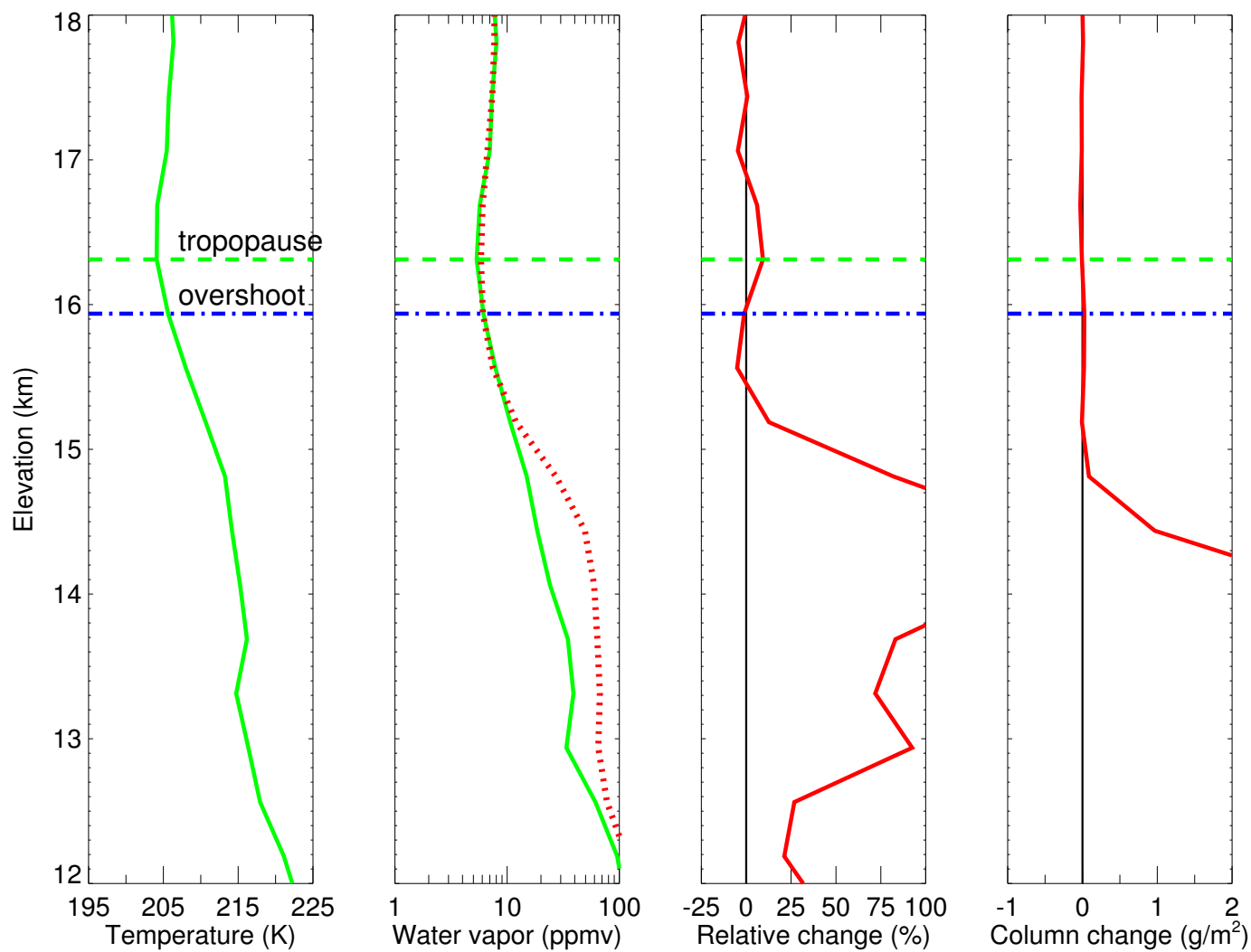


# July\_16\_PARSL

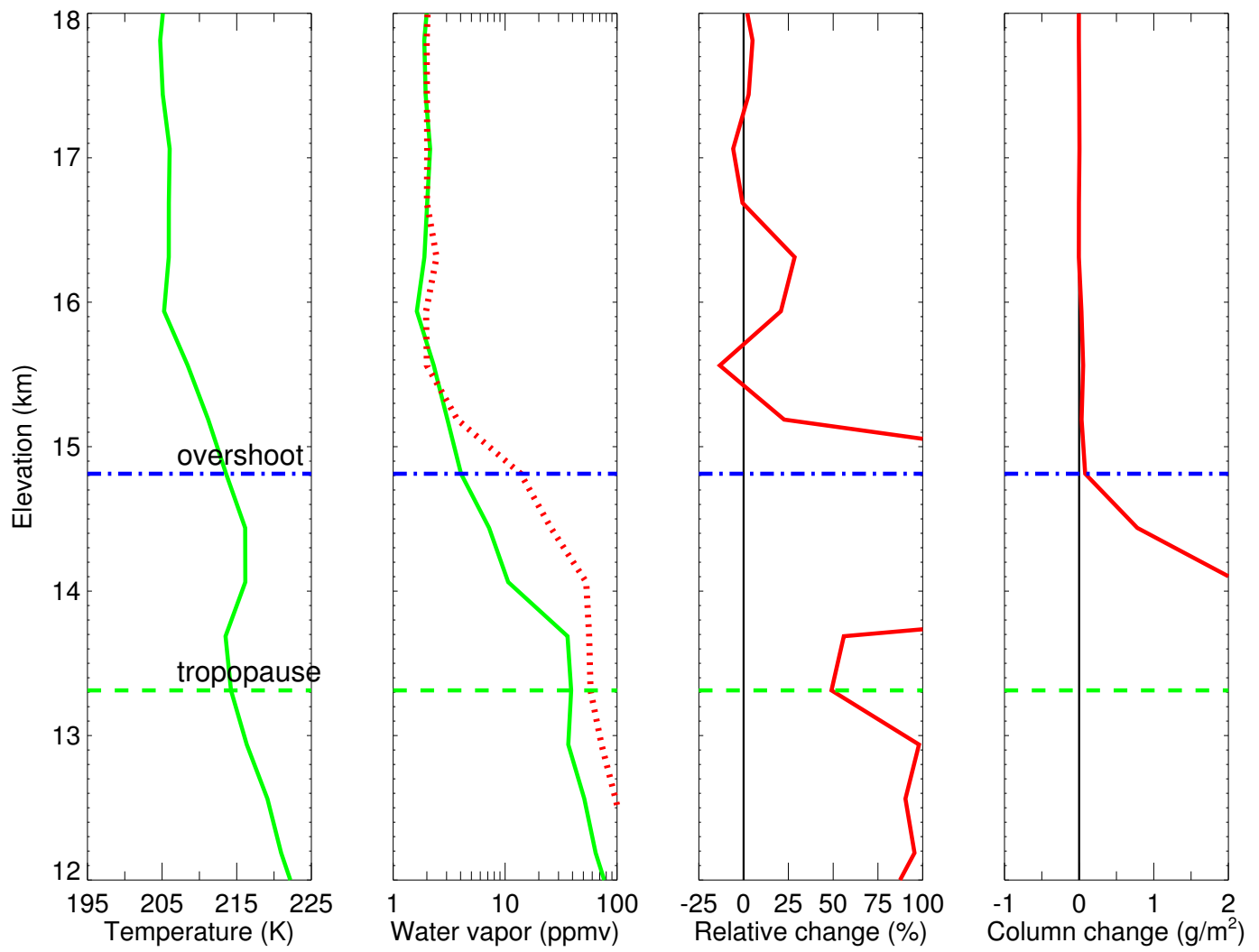




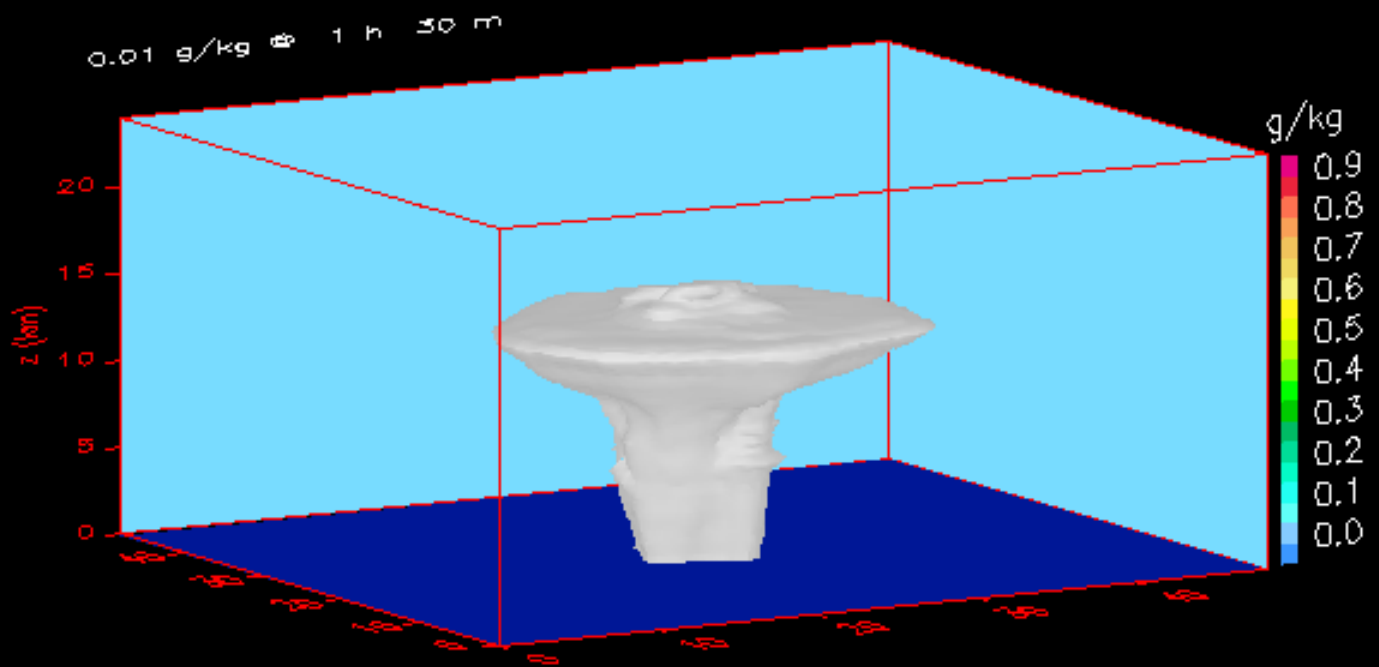
# July\_29\_Miami



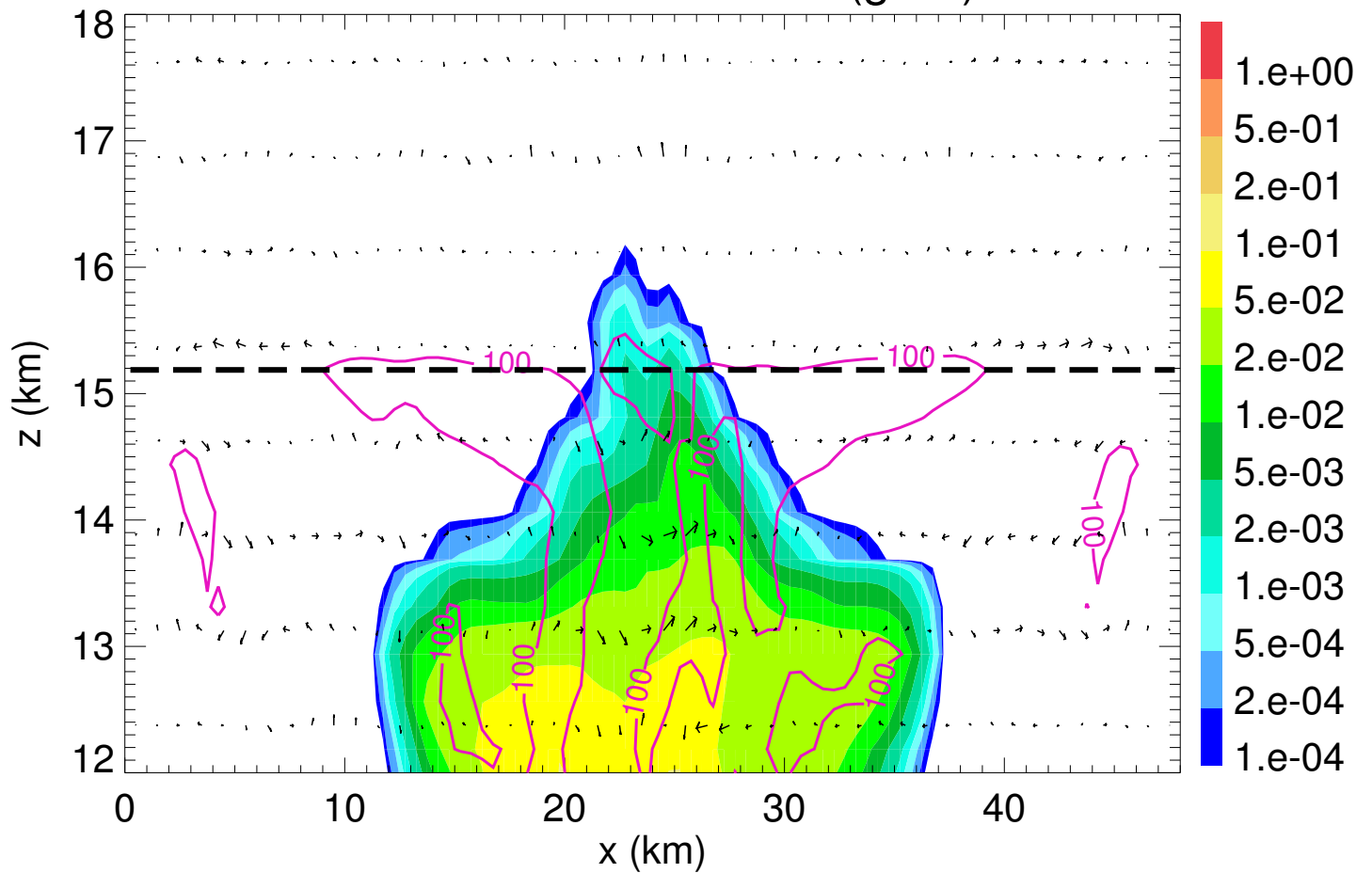
# July\_29\_PARSL



# Isosurface of Condensed Water



# Ice water concentration ( $\text{g/m}^3$ )



time = 1 hr 30 min,  $w_{\text{max}} = 0.3 \text{ m/s}$ ,  $u_{\text{max}} = 1.7 \text{ m/s}$

WB-57 FLIGHT TRACK  
JUL 11, 2002

TIME (GMT)

19: 21-19: 23

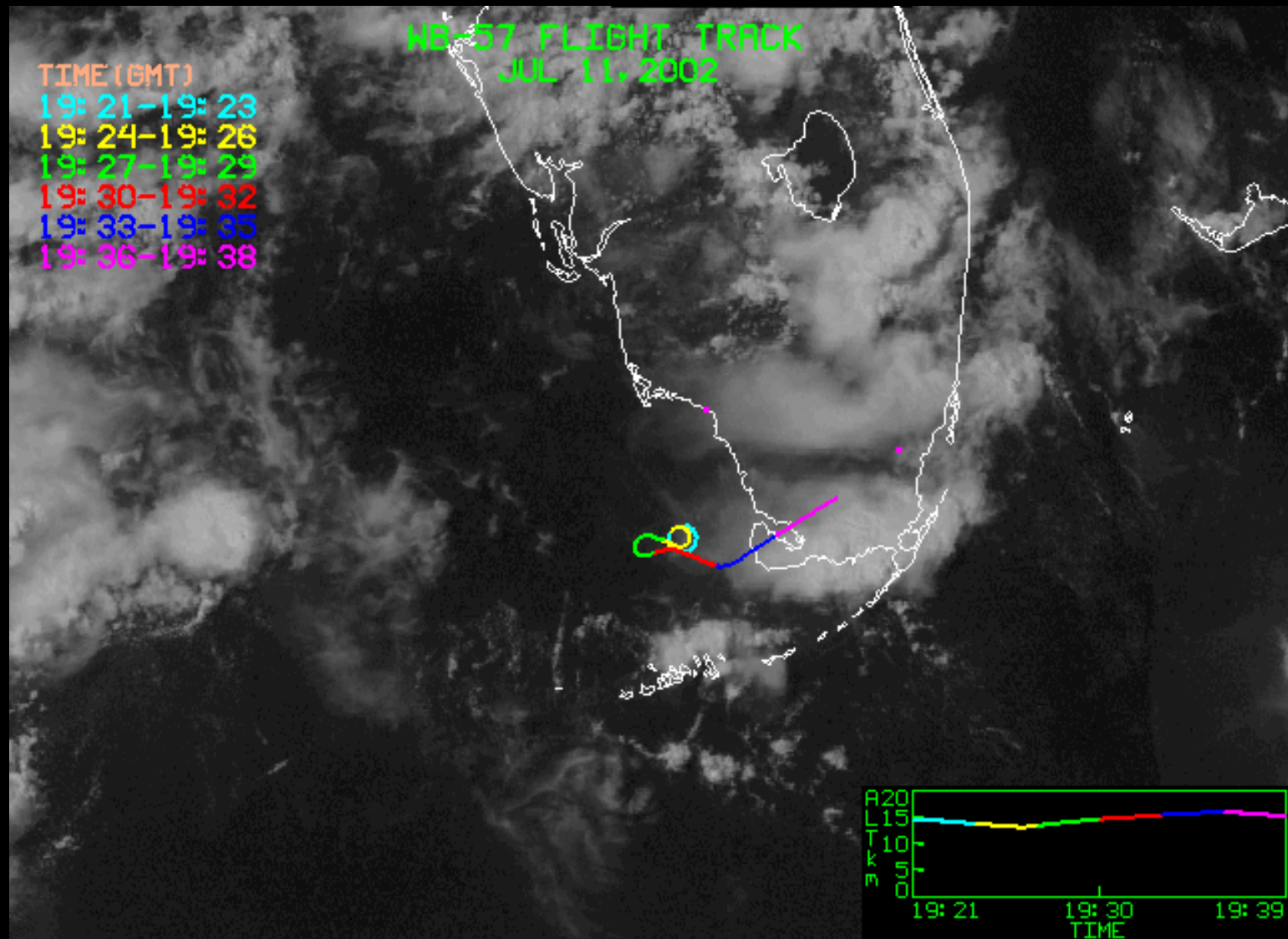
19: 24-19: 26

19: 27-19: 29

19: 30-19: 32

19: 33-19: 35

19: 36-19: 38

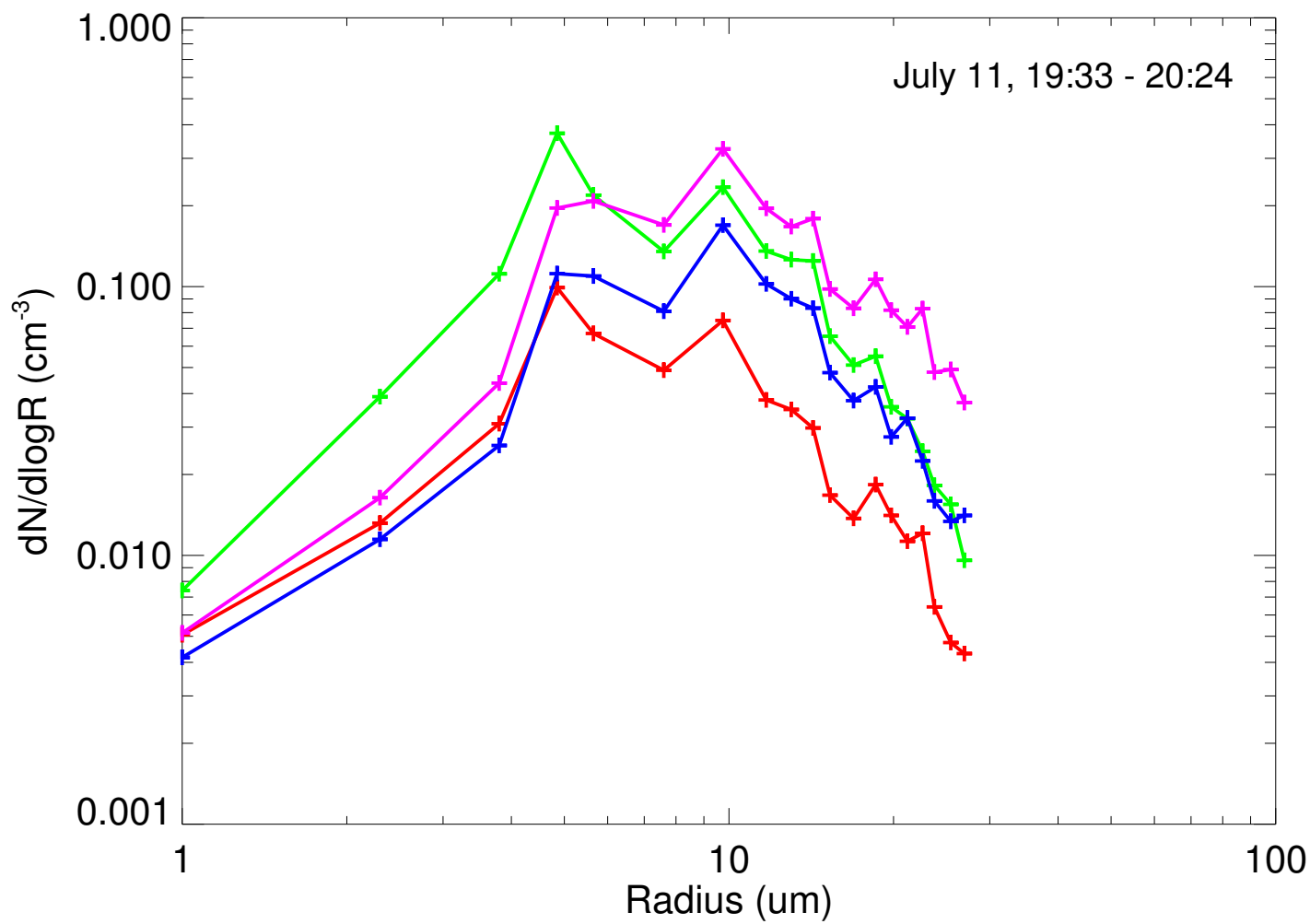


2 GOES-8 VIS 11 JUL 02 19:32 Z NASA LARC

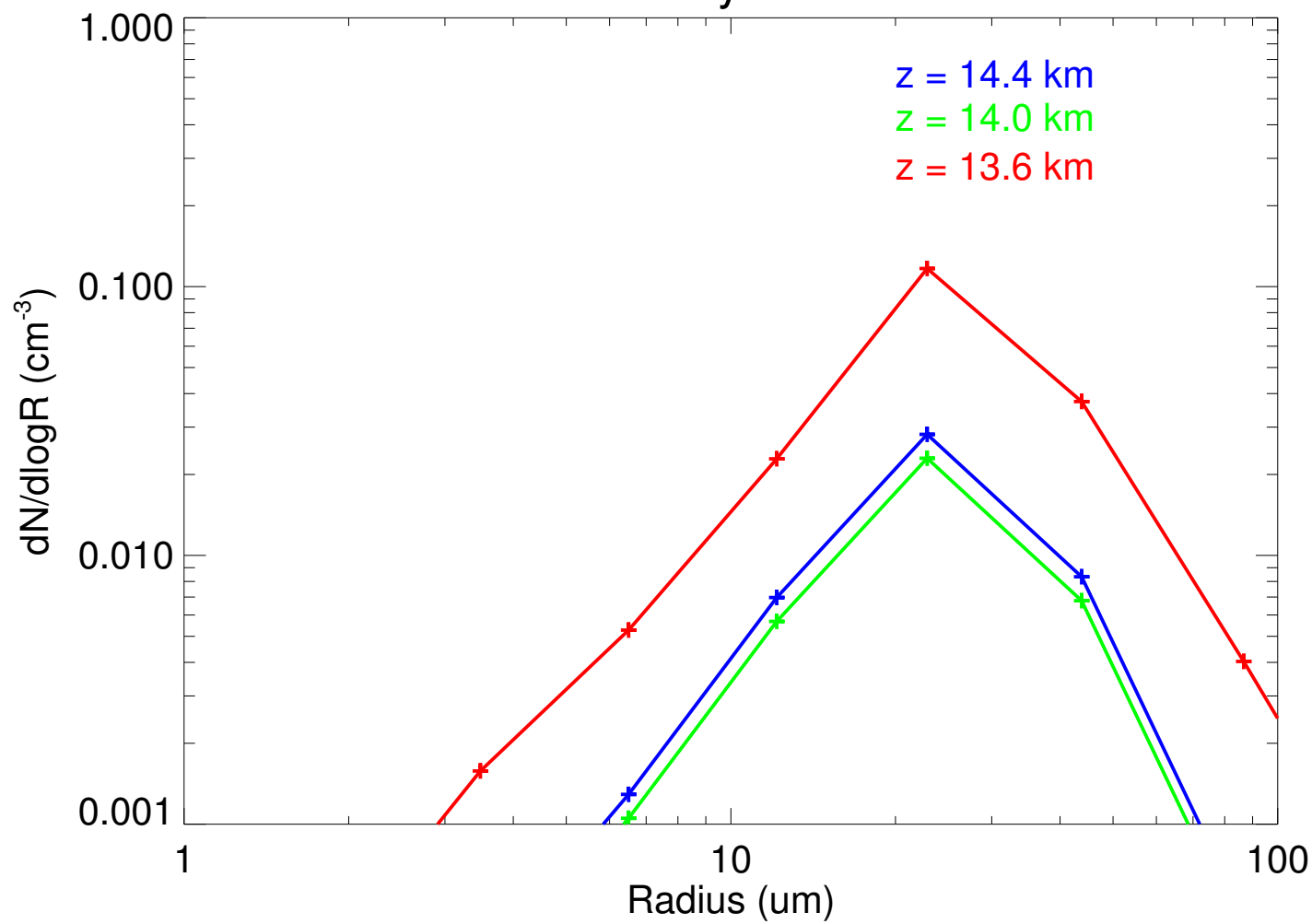
•W/E SITES

# SPP-100 size distributions

July 11, 19:33 - 20:24



# Simulated ice crystal distributions



# Summary

- Simulations provide no evidence for dehydration of tropopause layer by deep convection
  - Ice is lofted and evaporates faster than sedimentation can remove it in convective overshoots
- Significant disagreement in upper-level moisture between Miami (RS80-H) and PARSL (RS90) sondes
  - Instrument artifact or real spatial variation?



## Next steps

- Resolve radiosonde puzzle with *in situ* measurements of water vapor
- Explore sensitivities by varying aerosol concentrations, bubble strength, and initial soundings
- Analyze competing time scales (transport versus evaporation)
- Run cases from deep tropics mission